

REPORT 1965



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Experiment Station

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TO BRING YOU UP TO DATE . . .

As we go to press, we call your attention to two recent important events at the Northeastern Forest Experiment Station.

- In March, Richard D. Lane assumed office as new director of the Station. Mr. Lane previously served as director of the Central States Forest Experiment Station, which was disestablished in the recent reorganization. Mr. Lane is no stranger to the Northeast: in 1956-59 he served as chief of the Division of Forest Management Research at the Northeastern Station.

Mr. Lane succeeds Ralph W. Marquis, who had served as director of the Station since 1951. Dr. Marquis has joined the headquarters staff of the Forest Service at Washington, where he will be dealing with programs and legislation.

- Also in March, the Station moved from its headquarters office at 102 Motors Avenue, Upper Darby, Pa. Our new headquarters are still in Upper Darby, at the Center Building, 6816 Market Street.

— EDITOR

REPORT 1965

Northeastern Forest Experiment Station

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IN GENERAL

FOR the Northeastern Forest Experiment Station the year 1965 was one of new challenges, new opportunities, new accomplishments.

The regular appropriation bill for F.Y. 1966 brought increases in program funds for our maple-research project at Burlington, Vt.; our watershed-management project at Parsons, W. Va.; and our forest-products-marketing project at Princeton, W. Va. The increases bring these projects up to the levels projected in our short-term plan of research.

Additional program funds were received under the Appalachia program. These permitted us to activate our engineering-research project at Morgantown, W. Va.; to initiate a forest-products-utilization research project at Princeton, W. Va.; and to increase forest-survey and timber-quality studies at Upper Darby.

Certain restrictions on our activities have made us fully aware of the need to practice economy and increase efficiency in our operation. We now operate under ceilings governing the number of employees and their average grades and salary. We have been asked to cut travel cost to 90 percent of what we spent last year. We cannot buy new filing cabinets, or new office furniture.

In addition to complying with these regulations we have continued to effect changes, on our own, to reduce cost and increase research productivity. Consolidation of field locations has continued. The office at Elkins, W. Va., has been closed and all personnel are now located at the new laboratory near Parsons. Five scattered projects — white pine silviculture, northern hardwood silviculture, watershed management, forest pathology, and genetics have been brought together in one building and one administrative unit in Durham, N. H. The biometrics unit at New Haven has prepared computer programs that will permit us to do computation work at a yearly cost of

some \$300,000 less than under old methods. Our new system of distributing all Station publications to everyone on our mailing lists, though instituted for other reasons, has resulted in considerable savings in labor and mailing costs. All this enables us to put more of our research dollars into project work.

A Forest Service reorganization in the eastern regions is having considerable impact on our headquarters office, though little effect on our field projects. The reorganization is closing the Region 7 office in Upper Darby and the Central States Experiment Station headquarters office in Columbus, Ohio, and is creating two new area offices for the administration of cooperative state and private forestry programs (Atlanta and Upper Darby).

To the Northeastern Station this means the addition of two states — Ohio and Kentucky — to the area it serves. It means increased responsibility for the assistant directors and for all the supporting service units.

These are just highlights of some of our new challenges and responsibilities. They probably seem much more important to us than they do to you. So the rest of this report will be devoted to matters you care about most — the results of our past year's research efforts.

TIMBER MANAGEMENT

THE year 1965 marked an unusual number of changes and points of progress in timber-management research projects throughout the Northeast:

- The 3-man silviculture project at New Lisbon, N. J., was abolished in the interests of economy and because of the progress that had been made in completing assigned research objectives.
- The northern hardwood project at Laconia, N. H., was moved to a new location at Durham, N. H., thereby consolidating the administration and housing of the project with that of three other Station projects in water, genetics, and disease.
- The white pine silviculture project at Alfred, Maine, was combined with the genetics project at Durham to facilitate and concentrate the research effort on the genetics of white-pine weevil resistance.
- A second merger of projects took place at Burlington, Vt., where the seeding and planting of hardwoods project became a part of the maple sugar production project. There has been no change in the seeding and planting studies; the main reason for the merger was to consolidate and economize on the administration of the unit.
- William B. Leak transferred from the Assistant Director's staff in timber management research in Upper Darby to Durham, N. H., where he became project leader of the north-

ern hardwood silviculture project. David A. Marquis transferred from the hardwood project in New Hampshire to fill the opening on the Assistant Director's staff in Upper Darby.

- New scientists who joined the timber-management research staff in 1965 are Luther R. Auchmoody, soils scientist at Parsons, W. Va., and George E. Howe, geneticist at Burlington Vt. Auchmoody received his MS degree in 1965 at the State University College of Forestry at Syracuse University, and Howe received his MS degree in 1965 at the University of Washington.
- The Northeastern Station was a co-sponsor of a strip-mine symposium at Pennsylvania State University in October. The other sponsors of the symposium were The Pennsylvania State University and members of the Cooperative Research Committee on Coal Mine Spoil Revegetation in Pennsylvania.

With the closing of the New Lisbon project, Si Little and Horace Somes were transferred to the Upper Darby office. During 1965 their efforts went into continuing or completing the more important studies of that project.

The orchard of grafted pitch and loblolly pine seedlings was maintained, and its establishment was completed. Additional scions were collected from two loblolly and four pitch pines for grafting by Westvaco personnel. In the fall, grafted seedlings of these clones

were set out at New Lisbon, where there are now seedlings of 30 loblolly clones and of 30 pitch clones. During the year, seedlings planted a year earlier were periodically watered, fertilized, and treated for insect control; survival and growth have been good.

Recent information indicates that thinned loblolly pine plantations on typical sites in eastern Maryland are highly susceptible to *Fomes annosus*, but damage during a pulpwood rotation is negligible. In 1954-55 a row-thinning study was established in a 17-year-old plantation. The four treatments tested cutting of (1) every other, (2) every third, (3) every fourth, and (4) every fifth row. In 1961 *F. annosus* was found in all thinned plots, but little or none in the checks.

However, 10-year remeasurements showed: (1) that no dominant or co-dominant (or crop) trees had died during the 10 years in the heaviest thinning, and 5 percent or less had died in the other treatments; (2) that during the second 5 years, diameter growth of released trees in all treatments and crown classes was usually greater than that of check trees; and (3) that also, during the second 5 years, previous diameter growth rates were maintained or slightly increased only in the heaviest thinning, falling off in the lighter ones. Because the stands were already mature for pulpwood, *F. annosus* infections seem unimportant on similar sites for this crop. Whether damage will be important over sawtimber-piling rotations cannot yet be answered.

Two fairly new herbicides offer promise in controlling Japanese honeysuckle. Banvel D sprays containing 4 or 8 pounds acid equivalent per acre greatly reduced dense cover, but scattered regrowth developed and a re-treatment would be desirable. Tordon 101, which contains 0.75 or 0.54 pound of Tordon and 2 pounds of 2,4-D per gallon, eliminated all honeysuckle when a 3- or 5-gallon mixture

was applied per acre in a water carrier. A 101 treatment would be expensive (at least \$33 per acre for material), but might be considered for high-site areas where dense honeysuckle prevents establishment of forest stands.

BEECH — BIRCH — MAPLE

Durham, N. H.

The research program of the beech-birch-maple silvicultural project is now under review and analysis. Four problem areas have been recognized within the scope of the project: (1) growth and yield of trees and stands, (2) timber management, (3) soils and nutrition, and (4) silvics and silviculture.

Existing information within these problem areas is being carefully evaluated, and plans for future research are being charted with the dual objective of contributing to forest science and providing managers of beech-birch-maple forests with practical guidelines. Results from two studies, as described below, were among the highlights of the past year's research output.

Stump Sprouting

Stump sprouting in the beech-birch-maple type is of concern to both timber and wildlife managers. Timber managers are generally interested in limiting competition between sprouts and desirable regeneration. Wildlife managers often wish to encourage sprout growth as a source of browse for deer. To provide information needed by both types of managers, a study of the relationships between sprouting and certain characteristics of the parent stump and surrounding stand was conducted on the White Mountain National Forest.

A total of 172 stumps of red maple, sugar maple, paper birch, and yellow birch were selected and measured on cutover areas representing light, me-

dium, and heavy partial cutting and clearcutting. Multiple-regression techniques were used to relate both the number of 2-year-old sprouts and the average height of the tallest three sprouts to : (1) density of the residual stand measured in square feet with a 10-factor prism, (2) average diameter of the parent stump, (3) age of the parent tree, and (4) vigor of the parent tree as expressed by the past 10-year basal-area increment.

The analysis revealed that small stumps of red maple and sugar maple produced more sprouts than larger stumps. Furthermore, the smaller sugar maple and younger red maple stumps produced considerably taller sprouts. Red maple was the most prolific sprouter. Vigor of parent red maple trees was directly associated with number of sprouts but inversely related to average sprout height, the latter possibly because of competition among sprouts. Paper birth was the only species in the study that exhibited any relationship (inverse) between residual stand density and number or height of 2-year-old sprouts. Yellow birch proved to be essentially a non-sprouting species.

Thinning Young Hardwoods

In 1959 a thinning study was begun in a 25-year-old hardwood stand on the Bartlett Experimental Forest in New Hampshire. Three treatments and a control are being investigated: (1) *heavy crop-tree thinning*, the elimination of all trees competing with each marked crop tree; (2) *light crop-tree thinning*, the elimination of the one tree competing most actively for sunlight with each crop tree; (3) *crude thinning*, elimination of all over-story aspen, pin cherry, and striped maple, plus the thinning of each red maple sprout clump of three or more stems to the one best stem; and (4) *control*, no thinning.

Over a 5-year period, basal-area

growth and average diameter increment of the thinned crop trees have been at least one-third greater than that of unthinned crop trees. Among the various thinning treatments, growth was related directly to the amount of basal area removed. The annual basal area growth of the crop trees alone averaged 2.11 square feet/acre for the control and 3.22 square feet/acre for the heavy crop-tree thinning.

Although it is too early to make definite recommendations on the thinning of young beech-birch-maple stands in New England, results to date from this study indicate that early thinning of such stands may be an effective way to reduce rotation ages. Even the crude thinning, which requires little or no on-the-ground silvicultural expertise, produced a marked increase in growth. The more refined crop-tree thinnings not only produced significant growth responses, but also provided the opportunity for greatly improving the stand in quality, species composition, and spacing.

FOREST GENETICS

Durham, N. H.

Hybrid Poplar Research

The breeding and clonal testing of poplars in the Northeast has been directed toward the development of fast-growing, pest-resistant hybrids adapted to upland sites. A series of clonal test plantations including approximately 250 different hybrids were established on the Hopkins Experimental Forest at Williamstown, Mass., between 1949 and 1953. Five clones were included in each year's planting as standards against which the performance of the other clones could be measured. Data from these standard clones, now available for the plantings made in 1949, 1950, and 1951, illustrate hybrid poplar performance over a 15-year period (table 1).

Table 1. — *Height of 5 standard hybrid poplar clones 15 years after planting*

Planting site	Clone number					Average, all clones
	NE-20	NE-40	NE-216	NE-225	NE-327	
	<i>Feet</i>	<i>Feet</i>	<i>Feet</i>	<i>Feet</i>	<i>Feet</i>	<i>Feet</i>
Poorly-drained level	51	30	40	46	—	42
Well-drained slope	50	27	51	51	48	45
Average, all sites	51	28	45	48	48	44

Individual clones varied considerably in height growth and survival. Clone NE-20 consistently showed better height growth than the others, while clone NE-40 grew less than the others. Clones NE-216 and NE-225 had much higher survival than the other three clones. There were no survivors of Clone NE-327 on the poorly-drained level sites after 15 years.

Conditions of the planting site materially influenced survival and height growth: both were generally better on the well-drained slopes than on the poorly-drained level sites. However, clone NE-40 did not follow this pattern and NE-20 differed little in height on the two sites.

In these tests, inherent differences among clones and factors associated with the soil accounted for major differences in hybrid-poplar performance. Such clonal variation in response to site is a prerequisite for the successful combination of clones in a synthetic multiclonal hybrid variety. The genetic base for such varieties must be as broad as possible so that a sufficient number of individuals will yield a profitable crop over the wide range of environmental conditions normally encountered in reforestation.

The development of synthetic multiclonal hybrid varieties for maximum genetic improvement of forest trees is recommended by our principal geneti-

cist in several forthcoming publications (*Proceedings of the Advanced Study Institute for the Genetic Improvement for Disease and Insect Resistance of Forest Trees*, 1964; *Proceedings of the Northeastern Forest Tree Improvement Conference*, 1965).

Direct Seeding White Pine

A study of direct seeding white pine in Maine revealed that soil drainage conditions and degree of shade have major effects on seedling emergence. Study treatments included two degrees of shade (light shade equal to 85 percent of full sunlight and heavy shade equal to 40 percent of full sunlight), and two soil drainage conditions (a dry, excessively drained loamy sand and a moist loam). Several different local seed sources were also included in the study, but they had little effect on results.

On the dry soil, heavy shade greatly improved seedling emergence by conserving surface soil moisture. Emergence amounted to 70 percent of the seeds sown under heavy shade as opposed to only 46 percent under light shade. However, on the moist soil where surface moisture was not limiting, seedling emergence varied little, amounting to 82 and 85 percent of the seeds sown under heavy and light shade respectively.

MAPLE SUGAR PRODUCTION *Burlington, Vt.*

Sap-Production Techniques

The expansion of the maple sugar research project into the areas of sugarbush management, tree tapping, sap collection, sugarbush ecology, and sap-flow physiology, which began in 1964, was continued during 1965. This program, aimed toward ultimate lowering of production costs, is balanced between applied studies of immediate importance, and basic investigations leading to a more complete understanding of the sap-flow process.

In a study of off-season tapping, the total of winter plus spring yields from trees tapped in the fall (same tapholes reamed just before the spring season) was approximately equal to the yield of trees tapped in the spring only. Topographic aspect significantly affected winter yields: those from south and east exposures were greater than those from north and west exposures. The sugar concentration in winter-collected sap was significantly lower than in spring-collected sap from the same tree.

Other subjects now being studied include taphole healing, taphole markers, and the effects of bole temperature on sap flow and sugar concentration. Results of a 1965 exploratory study of chemical treatments to increase sap flow were very encouraging; such treatments will be investigated further in 1966.

Production of Superior Genotypes

Research efforts in 1965 continued to be concentrated on a survey-selection program for phenotypes that are superior in a sap sugar production. This year the program was again expanded and now includes Pennsylvania and six more counties in New York.

Except in these new areas, the patterns of variation among trees are fairly well determined.

The results of the survey to date, conducted primarily by service foresters and county agents in Maine, New Hampshire, Vermont, New York, Massachusetts, and Pennsylvania, are as follows:

	<i>Sugar bushes surveyed</i>	<i>Trees tested</i>	<i>Selected phenotypes</i>
<i>Year</i>	<i>(No.)</i>	<i>(No.)</i>	<i>(No.)</i>
1963	60	3,335	59
1964	92	8,253	152
1965	98	8,066	91
Total	250	19,654	302

In a study of the relationship between black maple and sugar maple, the two species were found to cross readily. How the characteristics of each are expressed among the progenies of this cross will be determined through study of the resulting seedlings.

A provenance study involving individual progenies from eight seed trees in each of 32 provenances is in process of establishment. Slow germination of a number of seedlots precluded any comparative observations during 1965. Stock is being grown at Burlington for field outplantings to be established both locally and at Parsons, W. Va.

Sugar Maple Establishment

A long-term study of sugar maple seed storage thus far has revealed that near-complete viability can be maintained through 3 winters (2½ years) after collection. The optimum storage condition appears to be at a temperature below freezing and at a seed moisture content near 10 percent.

Time of sowing sugar maple seed in the nursery significantly affects germination, survival, and seedling height growth:

	<i>Seed germination</i>	<i>Fall survival</i>	<i>First-year height growth</i>
<i>Sowing time</i>	<i>(percent)</i>	<i>(percent)</i>	<i>(inches)</i>
Fall	100.0	96.5	7.1
Spring	89.3	89.0	5.5



Wrapping a sugar maple tree with black plastic in an experiment to increase bole temperature, an important factor in sap flow.

As our experience in sugar maple seedling production increases, we continue to meet new and unexpected problems. The larvae of an anthomyiid (*Hylemya florilega* Zitt.), known to cause widespread damage among horticultural crops, has destroyed as much as 70 percent of our spring-sown seed in one bed. And despite fencing and baiting, fall-sown seed in another bed was almost completely destroyed by mice overwintering under the hardwood leaf mulch.

Although still in the early stages, a field planting study designed to test several site-preparation treatments and protection from wildlife damage has provided some interesting information. Spring survival of fall-planted 2-0 seedlings was exceptionally high under all treatments (98 percent). This indicates that, given reasonable care, sugar maple seedlings can be planted with assurance of a high initial survival. Further, a continuous snow cover such as usually accompanies northern Ver-

mont winters apparently provides almost complete protection against frost-heaving after fall planting.

However, most fall-planted seedlings suffered some winter kill of the terminals. The cause appears to have been incomplete hardening-off in the nursery before cold weather set in. Wild seedlings ordinarily harden off adequately and escape such injury. If the form and height advantage of nursery stock is to be maintained, a technique to induce earlier hardening-off in the nursery will have to be perfected.

SPRUCE-FIR

Orono, Me.

Current Trends

Current expansion of pulp and paper-mill capacity in the spruce-fir region has increased the demand for pulpwood. When this expanded plant capacity is in full operation, the annual pulpwood cut in Maine is expected to double for hardwoods and to increase nearly 25 percent for softwoods over that of 1964. Timber operators are finding it difficult to get woods labor; many of them are attempting to mechanize their woods operation to reduce the amount of hand labor.

One large timberland owner is testing a mechanical tree harvester in northern Maine. Another owner is expected to put a similar machine into operation soon. These two instances may signal the start of spectacular changes about to take place in the logging industry and in timber-management practices in this region.

The machine now in operation is being used to cut spruce-fir stands in narrow strips, leaving uncut areas between. Strips of different width and orientation are being tried. The track-mounted machine has a hydraulically-operated cutting boom that reaches out and grasps a tree, limbs it, clips off the top, shears it at the stump, and

deposits it in a pile in one continuous operation. A four-wheel rubber-tired skidder moves the piles of tree-length wood to a truck road.

Strip Cutting

Anticipating the introduction of the above machines, we began a study on the Penobscot Experimental Forest to provide information relating natural regeneration to strip width and slash treatment. As a part of this study, the amount of windfall is being evaluated on some 2 miles of forest edge. After the first year of exposure, one tree had fallen for each $3\frac{1}{2}$ chains of edge. Of the trees that fell, two-thirds were broken and showed signs of decay; more than 80 percent of the fallen trees were balsam fir. Nearly half of the windfall occurred along the edges of the 3-chain-wide cut strips.

At this early date, it does not appear that the forest edge created in this study will be subjected to an extraordinary amount of windfall. This is especially true of those edges that border 1- and 2-chain-wide cut strips.

Thinning White Spruce

The increases in circumference at breast height following a 1961 thinning in white spruce have been measured each year with dendrometer bands on individual trees. White spruce trees 70 to 75 years old and 5 to 6 inches d.b.h. were provided with crown release on 0, 1, 2, 3, and 4 sides. The growth patterns since thinning have been similar each year.

There were no significant differences in circumference growth between trees released on 0, 1, and 2 sides. Trees released on 3 or 4 sides showed greater growth than those in the other treatments; these differences were statistically significant after the third growing season. Rate of circumference growth for trees released on all 4 sides increased 2 times by the third year



A mechanical tree harvester in use in a northern Maine spruce-fir stand. The machine clearcuts a 50-foot strip at each pass.

stratification or for only 30 days after cold storage, was detrimental to germination.

Too Many Deer

A study of changes in the under-story vegetation of the 4,080-acre Tionesta Natural and Scenic Area on the Allegheny National Forest showed a slow but general decline in density and variety of the undergrowth over the past 20 years. In 1942, when the study was begun, most of the once-abundant witch-hobble in this virgin hemlock-hardwood forest had already disappeared. Practically no seedling reproduction of tree species can be found.

The cause is believed to be too many deer. Lack of predators and insufficient hunting pressure to control the deer population has created an unnatural situation. Observations on trends in the undergrowth—both herbaceous and woody—are being continued.

Red Pine Seed-Source Study

Red pine from 50 geographic-climatic seed sources ranging from Maine to Minnesota have been studied during a 25-year period in a plantation on the Kane Experimental Forest in northwestern Pennsylvania. Leader growth at 1 year and average total heights at 5, 10, and 25 years were significantly related (positively) to average initial green weights of the 2-1 planting stock. There was a small but significant relationship at 10, 20, and 25 years between average total height growth and latitude of the seed source: in general, seed sources from lower

and $2\frac{1}{2}$ times by the fourth year. These results indicate that white spruce needs release on at least 3 sides to benefit from thinning.

SILVICULTURE OF ALLEGHENY HARDWOODS Warren, Pa.

Seed-Handling Methods for Black Cherry

In a study of treatments to break dormancy of black cherry seed that had been stored dry at 34° to 38° F. or at room temperature for 15 to 16 months, none of three soaking treatments with chemicals (hydrogen peroxide, gibberellins, or citric acid) increased total germination. Seed stored cold and not treated chemically germinated about 63 percent after 90 days of cold, moist stratification; no benefits accrued from additional stratification up to 140 days. Room-temperature storage, whether continuous until

latitudes outgrew those from more northerly latitudes.

The best sources of red pine seed for planting on the Allegheny Plateau appear to be the lower peninsula of Michigan north of Saginaw Bay, the Green Bay region of Wisconsin, and south-central Wisconsin. However, even though statistical differences can be shown, the trees representing the various seed sources are relatively uniform in development.

Mine Spoil Revegetation

Through joint effort of the Northeastern Forest Experiment Station and the Pennsylvania Power and Light Company, a cooperative research program has begun in the Pennsylvania Anthracite Region in 1961. Information obtained from the studies conducted up to 1964 have already been put into practice by the Pennsylvania Power and Light Company in their program of tree planting to improve the aesthetics of the area. This program fits in very closely with the President's program to beautify America.

Repeated failures to establish trees on deep-mine spoils, especially on their southern aspects, led to two new studies in 1965 in which soil amendments of lime, fertilizers, and mulches were applied for the first time. Seeded and planted crownvetch (*Coronilla varia*) were used in one experiment and red pine and Japanese larch in the other.

The direct seeding of crownvetch was unsuccessful, but the crowns survived very well and produced a substantial amount of ground cover where lime and mulch had been applied. First-year survival and height growth of the red pine and Japanese larch indicate that lime treatment of deep-mine spoils is of prime importance. The mulches tested had only a slight effect on survival.

Red pine survival was somewhat better where a commercial fertilizer

was spread on the spoil surface around the seedlings, but both species suffered almost total mortality where a concentrated fertilizer tablet was placed in the planting hole. The tabulation below shows percentage of survival:

Treatment	Japanese larch		Red pine	
	Un-limed	Limed	Un-limed	Limed
Fertilizer tablet	0	2	0	2
Commercial fertilizer	0	50	14	47
Check	0	51	6	37
Average	0	34	7	29

In the Bituminous Region of Pennsylvania, where a cooperative research program has been in effect since 1958, many of the more obvious revegetation problems have been solved. However, survival of the commonly planted species has been unsatisfactory on extremely acid spoils (below pH 3.5). In the spring of 1964, 20 species and seed sources of alders, birches, locusts, and other promising trees and shrubs were test-planted on spoils ranging from pH 2.9 to 3.7. After two growing seasons, gray birch, European white birch (*Betula pendula*), and Scotch pine survived over 40 percent on the average, but no species performed well on spoils of pH 3.0 and lower.

Epicormic branching on a black cherry tree bordering a 12-year-old clearcut opening. Black cherry is one of nine hardwood species that were rated on their tendency to form epicormic branches.

SILVICULTURE OF APPALACHIAN HARDWOODS

Parsons, W. Va.

This project is concerned with the silviculture and management of the important northern Appalachian hardwood species. The major areas of study in the project include silvicultural systems, site relationships, timber quality, and natural and artificial regeneration. Results from three studies are discussed below.

Oak Soil-Site Study

This study showed that oak site productivity in the Ridge and Valley Region of West Virginia and Maryland can be estimated from an equation that relates oak tree height to five factors: stand age, aspect, slope position, thickness of the A and B horizons, and pH of the A₂ horizon. These

variables explained 68 percent of the observed variation; stand age alone accounted for 37 percent. For comparable soil conditions and topographic locations, site indexes in the Ridge and Valley Region run appreciably lower than in the Mountain Region to the west where annual rainfall is greater.

Epicormic Branching on Appalachian Hardwoods

From observations on 350 hardwood trees bordering clearcut forest openings in West Virginia, nine important species were rated as to their tendency to form epicormic branches. The species were grouped into four classes in order of decreasing susceptibility, as follows:

1. White oak
2. Black cherry
Red oak
Chestnut oak
3. Hickory
Yellow-poplar
Red maple
Sugar maple
4. White ash.

These observations confirmed previous tentative conclusions that, when the boles of hardwood trees in a stand are exposed by adjacent cuttings, more epicormic branches are produced on the second log than on the first, and more are produced by intermediate and overtopped trees than by dominant and codominant trees.

Three-Year Reproduction on Even-aged Compartments

Even-aged management studies in northern Appalachian hardwoods were begun about 5 years ago. Commercial, extensive, and intensive levels of management are being tried on three sites representing site indexes 80, 70, and 60 feet for oak. Ten, 20, and 30 seed trees per acre were left on site indexes 80, 70, and 60 feet respectively. The seed trees were left for 3 years to assure



an adequate seed source for natural regeneration of the stand.

Reproduction measurements on permanent plots were taken before and immediately after harvesting the seed

trees to determine the damage to the reproduction by logging. The average quantities and milacre stocking of the reproduction after removal of the seed trees are shown in table 2.

Table 2. — *Reproduction data¹ on even-aged compartments after removal of the seed trees three growing seasons after the initial reproduction cut*

Site index	Milacre stocking			Number of stems/acre		
	Seedling origin ²	Sprout origin ²	Not stocked	Seedling origin	Sprout origin	Logging damage to reproduction
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>No.</i>	<i>No.</i>	<i>Percent</i>
80	83.0	42.9	13.3	9,977	2,184	8.8
70	88.1	47.4	8.2	6,158	2,962	12.3
60	79.2	58.5	11.9	6,889	4,440	17.0

¹ Based on stems of commercial species 1 foot high to 1 inch d.b.h.; averages for 3 compartments per site class.

² Milacres stocked to both seedlings and sprouts are included in both columns.

WATERSHED MANAGEMENT

WATER shortages culminated in the Northeast during the late summer and early fall of the past year. Four years of cumulative drought brought this about. And what about next year? We have to assume that many municipal reservoirs will be low — even if normal precipitation occurs.

The drought has stirred interest in the possible application of timber cutting to increase runoff or water yield. This may be especially applicable to the removal of riparian and shoreline vegetation, but it also applies to clear-cutting forest stands either for timber production and water yield or for water yield alone.

Two watershed management symposiums in 1965, in which this Station was deeply involved, marked milestones of progress in this art. The first and largest was the International Symposium on Forest Hydrology sponsored by The Pennsylvania State University and the Northeastern Station among others, and held August 29 to September 10 at University Park, Pa. Researchers from 22 countries gave 87 papers covering the several fields of forest watershed-management research.

The second milestone was a Municipal Watershed Management Symposium held November 9-10 at the University of Massachusetts and sponsored by the Cooperative Extension Service, the Department of Forestry and Wildlife Management, and others. Interest in this field was attested by the attendance of more than 100 watershed managers and foresters. Four technical papers were presented by Northeastern Station researchers. Proceedings will be published for both symposiums.

WATERSHED CORRELATION & SYNTHESIS

Upper Darby, Pa.

This project is the latest addition to our watershed research program; it brings together new work in regional streamflow analysis and the cooperative program in municipal watershed research which used to be located at New Lisbon, N. J. The dual objectives are: (1) to assemble, correlate, and synthesize forest watershed research results and associated data for the prediction of the effects of forest watershed-management practices on streamflow; and (2) thorough research on municipal watersheds and correlative information, to determine the practices that will meet municipal water-yield and water-quality management needs.

Municipal Watershed Treatments

After 5 to 7 years of calibration, herbicides and cutting treatments were applied on cooperative watersheds at Newark, N. J., and Baltimore, Md., to determine the effect of vegetation removal on water yield. At Newark, riparian vegetation on watershed No. 1 was injected with a fast-acting herbicide; and on watershed No. 3 all of the trees on the area were injected and the understory was sprayed with herbicide. All of the trees and brush were removed from the riparian area of watershed No. 1 at Baltimore, and sprouts and other regrowth will be mowed for at least 2 years.

Special monitoring of water quality in streams where herbicides have been

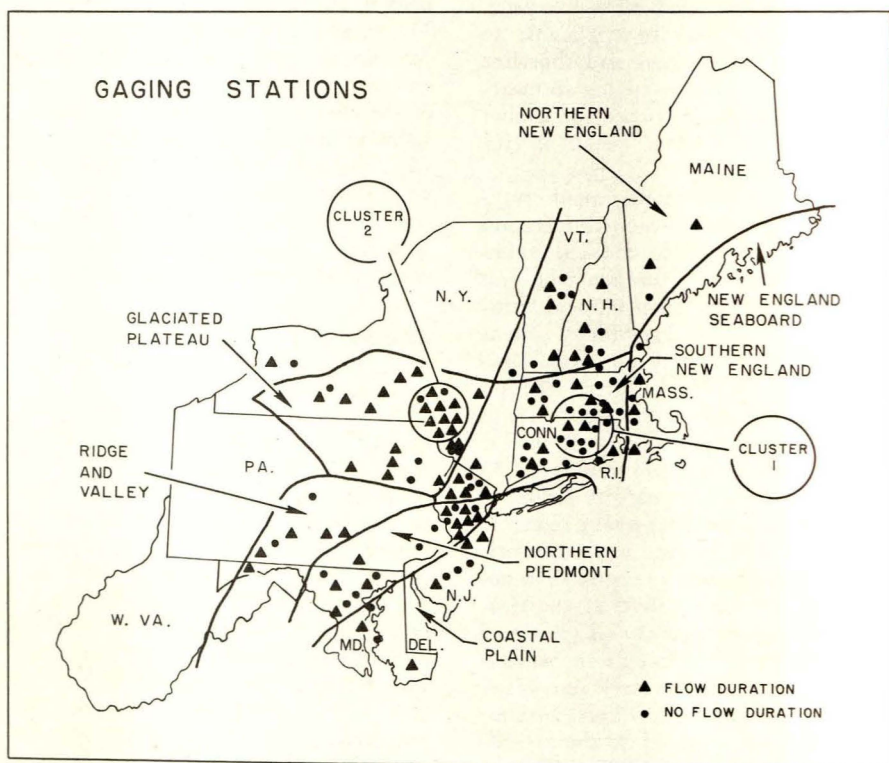
used on riparian and other watershed vegetation has shown that there is no detectable concentration of chemicals downstream, either right after spraying or after the first rain.

Regional Streamflow

An analysis of Northeastern streamflow based on 17 years of record at each of 137 watersheds will be published in the International Symposium Proceedings mentioned above. This study is a part of the Station's cooperative watershed research with The Pennsylvania State University. It included a comparison of water yields

and flow distribution by physiographic provinces, a multiple-regression analysis of independent variables related to water yield, and a comparison of streamflow of our experimental watersheds with that from neighboring and larger watersheds within the same physiographic provinces.

There were significant differences in average annual and seasonal runoff among the seven major physiographic units. Within units, average annual and seasonal runoff between watersheds were also found to be significantly different. There were even significant differences between watersheds clustered together in areas of a 20-mile radius.



The location of stream-gaging stations, by physiographic units. Northeastern streamflow was analyzed from 17 years of record at 137 watersheds.

Sources of these differences were sought by relating annual and seasonal flows and daily discharges at selected flow-duration levels to a series of 14 climatic, geographic, topographic, and land-use variables. Ten of these variables proved to have a significant influence; precipitation, percent forest cover, and mean maximum temperature for July were the most influential.

In three of the physiographic units, considerable correspondence was found between streamflow of small experimental watersheds and the streamflow of much larger watersheds in the same unit.

WATER YIELD IMPROVEMENT IN NEW ENGLAND

Durham, N. H.

Watershed Treatments

In the glaciated mountain area of New England, flood flows from spring rainfall and snowmelt, and low flows during summer and fall, are major problems confronting watershed managers. Summer water shortages have been accentuated in recent years by the critical northeastern drought. A beginning toward solution of these problems was made recently, when the first watershed treatment was completed on the Hubbard Brook Experimental Forest in New Hampshire.

After a 7-year calibration period, watershed No. 2 has been cleared of all woody vegetation. This treatment will provide a benchmark against which other watershed treatments may be evaluated. It represents the maximum reduction of transpiration that can be achieved, and should indicate maximum streamflow increases that can be obtained through forest manipulation. It will also provide information on ways of reducing snowpack and advancing the time of snow-melt runoff.

Watershed No. 2 is a south-facing area of 38.6 acres, covered with second-growth northern hardwoods. The treatment of this watershed was patterned after the one applied to Coweeta watershed No. 17, where all vegetation was felled and left in place. This avoided confounding of treatment effects that might have accompanied commercial logging. All cutting was done during the dormant season, thus enabling precise measurement of the effect during the growing season. Herbicide (both foliage and basal stump sprays) will be applied periodically for several years to eliminate regrowth.

Data Processing

A program for electronically processing streamflow records has been developed through cooperative work with Dartmouth College. With this program, streamflow data can be kept current to within 1 month of the recording date. In addition, the data are placed in a form that will enable numerous analyses that were impossible to make by former techniques. A similar data-processing program is being prepared for precipitation records.

Water Budget

Water received from precipitation may be stored in the soil or snowpack, lost in evapotranspiration, or run off the watershed as streamflow. Work under way on several studies is leading to a more complete understanding of this water budget and the effects of various climatic factors on disposition of water at specific times.

In one study, an equation is being developed to predict daily streamflow and soil moisture from known daily precipitation and from daily evapotranspiration estimates made from solar radiation, air temperature, and other climatic data.

In another study, actual evapotrans-

piration, as estimated by the water-storage equation using Hubbard Brook data, was found to agree closely with Thornthwaite's potential evapotranspiration. Actual evapotranspiration over 5 growing seasons (May 16 to October 15) averaged 18.9 inches, and the calculated potential evapotranspiration was 18.7 inches. This confirms the belief that soil moisture is sufficiently available throughout the growing season to meet the full demand made by potential evapotranspiration.

Measurement of soil temperature profiles and estimates of soil thermal conductivity have led to the conclusion that groundmelt of snow contributes water to streamflow even during below-freezing winter temperatures. Heat conducted from within the soil to the bottom of the snowpack causes the snow to melt. This groundmelt can account for sustained winter streamflow of 0.007 to 0.02 area-inches of water per day.

STREAM REGIMENS IN NEW YORK

Syracuse, N. Y.

The past year has brought about expansion in facilities and programs at this project. In conjunction with the College of Forestry, a field laboratory suitable for micro-meteorological and soils investigations was established in a red pine plantation on the Pack Forest at Warrensburg, N. Y. Eight 70-foot triangular-shaped towers and two 100-foot aerial tramways have been erected in the area. An irrigation system covering $1\frac{1}{2}$ acres, and 40 neutron meter access-tubes were also installed. A power line was constructed so that any portion of the area can be supplied with a stable source of A. C. power. Studies inaugurated in this field laboratory include investigation of spacial variation of albedo, net radiation, surface temperature, and soil moisture,

as well as temperature and wind profiles.

Work on a standards laboratory is in progress, consisting of high precision voltage-measuring devices, amplifiers, and power supplies. It is expected that within a short time all of our electronic temperature-measuring devices will be calibrated to a minimum 0.2° C. level.

Solar Radiation Relationships

Approximately 4,000 measurements have been taken during the past 6 months in an investigation of the amount and spacial variation of reflected short-wave radiation above a pine plantation. Data are recorded on strip-chart recorders from Moll-Gorczynski type solarimeters as they pass along cable tramways above the forest canopy. A computer program has been prepared to transform the field data into energy units and reflectivity ratios (albedo). This investigation will soon be extended to include net radiation.

Reflectivity ratios along a 100-foot tramway at midday in July under clear sky conditions ranged from 0.0971 to 0.1170 with a coefficient of variation of 6.3 percent. Under full cloud cover at midday in December, the reflectivity ratio along the same tramway ranged from 0.0756 to 0.0892, with a coefficient of variation of 5.5 percent.

Streamflow Analysis

Application of a "flow interval method" developed by this project to the discharge data from four differently treated watersheds on the Fernow Experimental Forest in West Virginia has shown that harvesting changes the length and timing of the various flow intervals. In general, the 25- and 50-percent flow intervals (used as measures of peak streamflow concentration) may be either lengthened or shortened, depending on the

intensity of cutting and the number of years since harvest. In nearly every instance, harvesting shortened the length of the 1- and 5-percent flow intervals (used as measures of low flow).

Dates of mean-flow occurrence for the peak-flow intervals were not affected to any extent by cutting. However, the analysis indicated that low flows were started later in the year because of increased discharge during the summer.

FLOODS & WATER YIELDS IN THE NORTHERN APPALACHIANS

Parsons, W. Va.

Benchmark watersheds on the Fernow Experimental Forest continue to yield results that corroborate and expand the conclusions reached from the earlier studies. The major conclusions are:

- A heavy timber cutting can produce a large increase in water yield.
- Low flows are greatly increased.
- Increases in high flows are relatively slight.
- Yield increase depends upon the amount of timber cut, not on the way the logging is done.
- Damage to water quality depends upon the way the logging is done, not on the amount of timber cut.

There are two benchmark watersheds on the Fernow; each is about 60

acres in area. Vegetation on half of each watershed has been removed by logging and herbicides. The increases in water yield following treatment have been striking. The expected stream discharge for the two watersheds (if there had been no treatment) and the actual increase, in thousands of gallons per treated acre, were:

<i>Period</i>	<i>Expected</i>	<i>Increase</i>
May 1964 to Oct. 1964	90	132
Nov. 1964 to Apr. 1965	533	89
May 1965 to Oct. 1965	20	165
Total	643	386

The increase in water yield averaged 700 gallons per acre per day over the 18 month period — an increase of 60 percent. Timing of the increase was equally encouraging. During the two growing seasons, the average increase amounted to 800 gallons per acre per day; this represents an increase of 270 percent over the flow that would have been expected had there been no treatment. Thus low flows were definitely augmented, but the effect on high flows was relatively small. Furthermore, the increases occurred during 1965, the driest growing season in the 15-year record at Parsons.

In this study, the cutting of timber was complete, but care was taken in the logging. Nearly 100 water-quality samples were collected from each stream during logging and the 6-month period following. Although most of the samples were clear, a few taken during storms had slight turbidity. But the maximum of 85 turbidity units is not high enough to cause alarm.

FOREST ECONOMICS

ECONOMICS OF GOVERNMENT FORESTRY PROGRAMS

THIS project aims at developing information needed by administrators of government forestry programs for evaluation of alternative assistance programs and program activities. Forestry assistance programs operate under limited budgets. Decisions to invest funds in one program or activity within a program must consider the costs and benefits associated with other programs and other program activities. This type of information is needed both for the evaluation of current assistance activities and for identification of areas of need not presently covered under current programs.

ECONOMICS OF CURRENT PROGRAMS

A study designed to measure the costs and returns associated with the various forestry activities currently undertaken by Pennsylvania landowners with cost-sharing assistance under the Agricultural Conservation Program and technical assistance under the Cooperative Forest Management Program is nearing completion. Preliminary analysis indicates that some reorientation of the activities undertaken with assistance from these programs would be profitable. For example, in some sections of Pennsylvania the Government's costs of providing financial and technical assistance for planting and timber-stand-improvement practices exceed the dis-

counted values of timber products that will be available from the plantation or treated stand.

REGIONAL SUPPLY-DEMAND STUDIES

A prerequisite to the evaluation of assistance programs is a knowledge of what future problems are likely to occur in the region's forest economy, where they will occur, and why they will occur. Workable knowledge of the whats, wheres, and whys in turn requires quantitative and qualitative identification of present and likely future timber supply-demand relationships in much greater detail than is now available.

To help meet these needs, we have begun work on the development of a dynamic simulation model of the forest economy of the Northeast. The model has four sectors: timber-products requirements, timber-products availability, stumpage requirements, and stumpage availability. When complete, the model can be used in projecting future regional demand and supply conditions for timber products and stumpage. Its primary uses will be for identifying areas that need government assistance programs and for studying the effects of new programs or changes in existing programs.

Although the model is not yet operable in a mathematical sense, it is being used as a guide for establishing research priorities. It has shown, for example, the need for detailed knowledge about the economic availability of physically available stumpage. Con-

sequently, we have initiated two cooperative studies in this area with Yale University. In another cooperative study, also with Yale University, we have undertaken a study to determine the stumpage source, marketing, and use of fuelwood — southern New England's most important forest product.

ECONOMICS OF TIMBER GROWING

During the past several years, we have discussed the possibility of constructing timber-supply schedules for major timber species in the Northeast. These schedules would provide economic evaluations of the timber-supply response to added units of investment in timber growing. They would be useful in evaluating economic impacts of alternative forestry programs and in projecting land-use patterns.

One of the reasons that work has not moved ahead rapidly in this area is the lack of information about major species. Economic information must be combined with biological information in evaluating the growth response achieved through various cultural practices. These practices include not only thinning and timber-stand improvement, but such practices as spraying to control insect and disease pests. Eastern white pine is the only species for which such data have now been assembled.

An economic analysis of several pest-control and management alternatives for white pine in the East was started 5 years ago. The major output of this project is summarized in two research papers. The first of these, which was published in 1964, dealt with evaluating and scheduling white-

pine weevil control in the Northeast (*U. S. Forest Service Research Paper NE-19*). The second of these papers, which is to be released early in 1966, presents economic guides for blister-rust control in the East (*U. S. Forest Service Research Paper NE-45*).

Both of these papers present evaluations of pest-control opportunities (1) in terms of a set of conditions that must be met if stands of white pine are to be considered for control and (2) in terms of the kinds of information that are required to evaluate the opportunities presented in each stand. These two publications cover the economic analysis of the most important insect and disease pests that affect white pine in the East.

To make these analyses, it was necessary to bring together information from research projects conducted in a number of places over a long period of time. This information, which constitutes one of the more complete sets of data on the growth of white pine under various conditions, has been published as *The Mensurational Characteristics of Eastern White Pine* (*U. S. Forest Service Research Paper NE-40*). In addition, a cooperative project on the financial maturity of white pine was completed at the New York State College of Forestry. These studies together provide information that can be used to develop supply schedules for this species.

A study of timber-stand-improvement opportunities in the oak-hickory type is nearing completion. This study will provide estimates of rates of return for various conversion and TSI opportunities under a variety of conditions. This is the first of a series of studies of hardwood management economics that are planned.

FOREST SURVEY

THE Forest Survey forest-inventory program moves from state to state in the Northeast. Each state usually requires a separate survey. During 1965, various phases of the regular state surveys were being conducted in five states. In addition, work under the Appalachian Development Act was started in another state and a pulpwood production survey was being conducted throughout the entire Station territory.

STATE INVENTORIES

Maryland

A draft report on the timber resources of Maryland was prepared in 1965 after we had received from the Maryland Department of Forest and Parks their estimates of timber-products output by species. The findings of this survey, which was made 14 years after the initial survey, reveal little change in the estimate of total commercial forest land and an increase in total timber volume. The highlights of the report are:

- Commercial forest land amounts to 2,885,000 acres, a decrease of less than 1 percent.
- Growing-stock volume adds up to 2,961 million cubic feet, an increase of 6 percent.
- Sawtimber volume amounts to 6,823 million board feet, an increase of 3½ percent.
- Fifty-three percent of the sawtimber volume is in trees 15.0 inches d.b.h. and larger.
- Considerable changes in sawtimber

volume by individual species took place; for example, loblolly pine decreased by 17 percent, sweetgum decreased by about one-fourth, and yellow-poplar increased by about one-third.

- Net annual growth is 94 million cubic feet for growing-stock and 204 million board feet for sawtimber.
- The annual cut is about 74 million cubic feet of growing stock and about 234 million board feet of sawtimber.

Pennsylvania

Data processing of field-plot information collected in 1963-64 has been completed. Information on timber-products output is being summarized and resource statistics are now being compiled for the timber-resource report. Preliminary resource tables will be available this summer.

Vermont

Field work for the resurvey of Vermont was completed in 1965. This includes the cooperative inventories on the Green Mountain National Forest and on lands of the Vermont Department of Forests & Parks.

New York

Plans have been made for the resurvey of New York. Photo interpretation was begun in December and field work for the western half of the state will be completed in December. Field and office work for this survey will be completed by the end of 1968.

Ohio

As a result of the reorganization in the Forest Service, Ohio was added this year to the Northeastern Station territory. Plans were made for the second survey of the state.

APPALACHIA PROGRAM

A complete canvass of 1965 timber-products production in West Virginia has been started as part of the Station's effort under the Appalachian Development Act of 1965. Information about the production of forest products—such as lumber, pulpwood, mine timbers, charcoal wood, turnery bolts, barrel staves, veneer, and fuelwood—will be included in the canvass. The Extension Forester and State Forester and their staffs are cooperating in the canvass.

This timber-demand information, together with timber-supply data, will offer a much more complete resource picture for decision makers regarding industrial development and expansion than has been available before. Similar data for Maryland and Pennsylvania

portions of Appalachia has been collected in connection with recent forest surveys.

PULPWOOD PRODUCTION IN THE NORTHEAST

Our Forest Survey staff began a pulpwood production survey in 1964 for a 7-state area of our Station territory. This has since been expanded to include the entire Station territory. These annual production surveys are seen as a step toward providing a more complete picture of the timber-resource situation.

Pulpwood production in the Northeast rose to 4,372,200 cords in 1964 from 4,270,700 cords in 1963. Production of round pulpwood rose 2 percent between 1963 and 1964, from 3,990,000 cords to 4,074,000 cords. Pulpwood chip production showed a substantial increase from 277,600 cords in 1963 to 287,400 in 1964. The use of other wood industry byproducts is also on the increase: byproducts accounted for 10,100 cords in 1964, up from 3,100 cords in 1963.

FOREST RECREATION

SYRACUSE CAMPUS

Cooperative research with Syracuse University and the New York State College of Forestry, particularly where graduate students are involved, is helping to create interest in recreation problems and to develop students with research capabilities in forest recreation. We are now assisting two Master's and two Ph.D. candidates who are investigating interrelations between recreational use and natural resources.

In recognition of the variety of future outdoor recreation requirements, one of our current studies of recreation demand explored the question: What influences the decision to camp at a particular park? Responses to personal interviews at five parks throughout eastern and northern New York State were summarized under six major factors: nearness of the campsite to water, swimming and water-sports accommodations, variety of landscape, nearness of tourist attractions, recommendations by friends, and nearness to home. The percentage of camping parties who mentioned each of these six factors differed significantly among parks and also throughout the summer months at any one park, thus pointing up the extreme variability in recreation-demand patterns for individual campgrounds.

Differences in socioeconomic characteristics and objectives of campers at any one park, as well as significant differences among parks in terms of use intensities, suggest that demand patterns for individual camping areas are unique and independent of one another. Furthermore, demand for camp-

ing areas seems to be affected by the predominant features of the natural environment — particularly those features related to water.

WARREN LABORATORY

Both public and private forest recreation managers have become increasingly aware of the need for better operating guidelines. Management decisions involving such problems as (1) finding the best locations for new recreation enterprises, and (2) providing the most acceptable types of facilities and services for increasingly specialized recreation demands, are being made without benefit of market research. The orientation of the Station's regional recreation project was narrowed in 1965 to help remedy this situation.

The objectives of the recreation project at our Forest Recreation and Wildlife Laboratory at Warren, Pa., are to develop basic information about the characteristics of several forest recreation markets in the Northeast. Identification of geographic recreation market areas, their physical features, ownership composition, past recreational demands, visitor characteristics, and development potential will provide a basis for further research. At the same time, these descriptive studies will help to satisfy the growing need for better investment information for the outdoor recreation industry.

Success of Private Campgrounds Studied

A useful application of the recreation-market-area orientation was re-

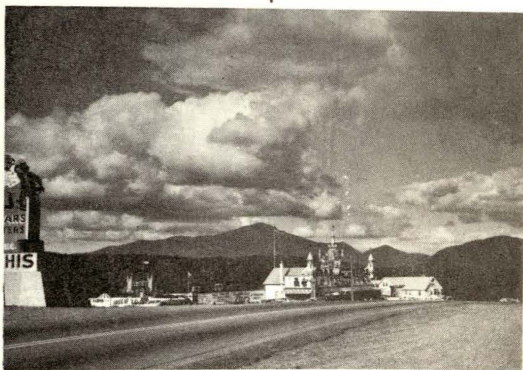
POPULATION CENTER

1. TRAVEL TIME TO
THE CAMPING AREA.

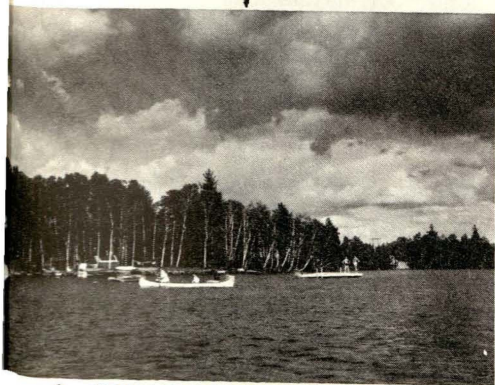
6. CAMPING AREA
RECOMMENDED
BY FRIENDS.



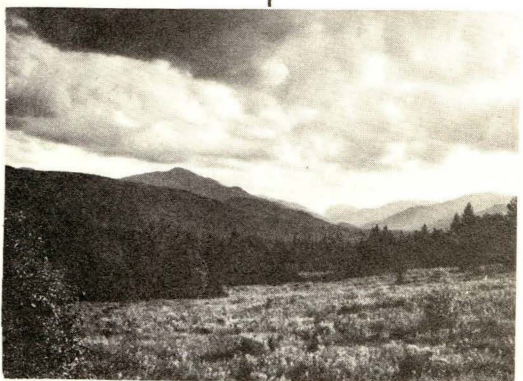
2. NEARNESS TO WATER.



5. TOURIST ATTRACTIONS
NEARBY.



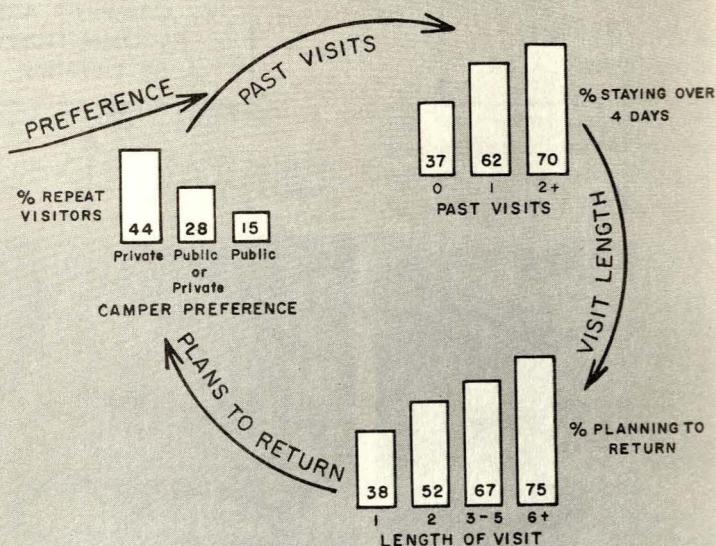
3. SWIMMING AND WATER
SPORTS ACCOMMODATIONS.



4. VARIETY OF LANDSCAPE.

Six major factors that influenced use at five public camping areas in New York State. The relative importance of each factor differed significantly among the campgrounds considered.

The Repeat-Visit Cycle



A circular relationship connects the variables of frequency of past visits, length of current visit, and intentions of returning for a future visit, among campers at New Hampshire's private campgrounds.

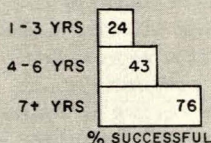
vealed through our recent cooperative study of private campgrounds in New Hampshire. Camping enterprise success, and certain elements of camper behavior, were found to vary widely among three regions of the state that have distinctly different types of outdoor recreational attractions. Also, campers visiting successful private campgrounds spent more days per visit, and were more likely to have reserved their campsites in advance, than those visiting the less successful enterprises.

Campground owners need to understand the factors that affect the length and frequency of camping visits. Because camping is a popular week-end activity, many camping enterprises are poorly attended during the week. Our analyses of more than 1,000 questionnaires indicated that this is not a rigid camper behavior pattern. Camping visits of 4 days or longer may occur in response to several variables of the campground, and of the camper.

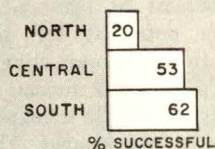
Variables of the campground that affect use include location, size, and

Success Factors for Private Campgrounds in N. H.

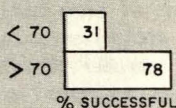
AGE OF ESTABLISHMENT



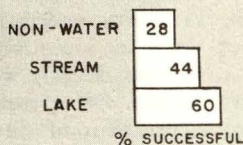
REGIONAL LOCATION



NUMBER OF FAMILY UNITS



TYPE OF ATTRACTION



Percentages of successful private campground enterprises in New Hampshire, according to the number of years in business, location within the State, campground, size, and type of recreational attraction at the campground.

water attractions. Variables of the camper include length and variety of past camping experience and motivation for camping.

Recreation Impacts on Vegetation

A 3-year summary of changes in ground cover on an Allegheny National Forest campground has shown some interesting trends in vegetative composition and density. Campsite cover that had been heavily worn during the first year of recreational use

recovered, and has thrived, during the second and third years in spite of continued heavy use. Between 1963 and 1965, there has been a natural increase in more durable fine-leaved grass species; this has been accompanied by a marked decrease in broad-leaved species. Average use and percentage of barren ground during the past 3 years show this increase:

Year	Average camper-use (days)	Average extent of barren ground (percent)
1963	230	39
1964	264	37
1965	336	26

WILDLIFE HABITAT

OUR wildlife-habitat-research program continues to be devoted to problems in habitat-timber relations. The potential for general improvement in the habitat appears to depend largely on the success with which timber and habitat management objectives can be coordinated. The recent advent of even-age management systems in northern hardwood stands has made this coordination vital.

Seven of the 13 studies undertaken by the project since its inception 6 years ago are concerned directly with habitat-timber relations. Other studies on the important problems of direct habitat improvement and the ecology and nutrition of wildlife plants are being conducted in cooperation with the Fish and Wildlife Service and The Pennsylvania State University.

HABITAT-TIMBER RELATIONS

A new method of intermediate cutting that yields deer browse and small game cover, as well as better timber, is now being used on the Allegheny National Forest. The method was developed for use in northern hardwood poletimber stands, which are generally low in value for wildlife.

All stems except selected crop trees are felled during the winter season and an attempt is made to hinge the stem to the stump so that the tops will remain alive to produce browse and cover in subsequent years. The method was found to yield 141,000 twigs of deer browse per acre in the first year, a tenfold increase over that in unthinned stands. The yield in dry weight

stump sprouts and twigs is about 70 pounds per acre.

The cuttings are made in blocks about 10 acres in size and are distributed at approximately $\frac{1}{2}$ mile intervals in poletimber stands. The location of the cutting is determined after wildlife needs have been integrated in the overall planning for each management unit—an area of 300 to 500 acres. This method, which costs \$35 to \$40 per acre, also provides a greater release of crop trees than does girdling of competing stems only, which costs \$10 to \$15 per acre.

In a related study in poletimber stands, information has been gathered about the browse-producing capabilities of the stumps of hardwoods of nine species. Stumps of six commercial species (black cherry, sugar maple, red maple, white ash, basswood, and beech) produced an average of 26 sprouts per stump the first growing season.

Basswood was the most prolific sprouter, followed by black cherry, red maple and beech. Sprout production in white ash and sugar maple was about one-third that of black cherry. More than 90 percent of the sprouts of black cherry, red maple, and white ash were browse. A somewhat lower rate of utilization occurred on basswood and sugar maple, and only one-third of the beech sprouts were browsed.

COOPERATIVE STUDIES

A study of the nutritional content of black cherry and beech browse was started this year as a cooperative study with the Department of Animal Industries and Nutrition of The Penn-

sylvania State University. Buds and woody sections of sprouts and seedlings will be analyzed by seasons to establish crude protein levels for these species. The distribution of samples of plant parts is related to differences in their use by deer.

The occurrence, growth, and ecology of all woody vegetation protected from

deer browsing is being studied in different hardwood stand conditions in Pennsylvania. This study is in cooperation with the Fish and Wildlife Service. Seven exclosures were distributed in clearcut areas, savannah vegetation, and poletimber stands. All of the areas are under heavy pressure from deer browsing.

FOREST INSECTS

RESearch can be likened to mass warfare in many ways. The competitive aspects differ in degree, generally, but the elements of strategy and much of the tactical maneuvering to gain stated objectives are essentially the same. In militaristic terms, we simply have consolidated our position this year.

Two research scientists and two biological laboratory technicians were added to our staff at West Haven, Conn. Training programs were given increased emphasis. Much needed new equipment and special apparatus were purchased. A 4-room, fully equipped, field laboratory was constructed at the Saltonstall Experimental Area in Branford. The 10-acre site for our new laboratory in Hamden was acquired, and final plans for the laboratory were approved, ready for preparation of specifications for construction and the awarding of a contract.

Several major studies, including the life history of the white-pine cone beetle and the mode of dispersal of the pine leaf aphid (carried out as a cooperative aid project with the School of

Forestry of Yale University) were completed. Other studies in progress were continued or extended, as warranted. Research was initiated on the separate culture of insect cells and tissues. Some highlights of the work in 1965 follow.

INSECT BIOLOGY

Studies in insect-population ecology are difficult when insect numbers are low. Traditionally, a point is reached when the researcher becomes convinced that other matters require his attention. Yet the events occurring in that part of the cycle when the insect is very sparse must be observed and analyzed for two reasons: (1) to determine what agents or processes are important in holding the population at a low level, and (2) to determine what factors affect the intensity and duration of their actions—why and when is the insect population “released.”

Intensive sampling was conducted and detailed observations were made of the behavior and survival of the gypsy

moth in the Natchaug and Nipmuck State Forests in Connecticut. Records of the gypsy moth in the general area of these Forests indicated only sparse populations for 30 years or more, even though the forest type is predominantly mixed oaks, and seemingly suitable for the insect. Attention was focused on the larger caterpillars as they became more aggregative, and counts at 3-day intervals revealed the patterns of movement and niche use on host trees.

It was shown that the insect tended to stay during daylight hours in certain kinds of niches if they were available on the tree. If these niches (primarily large bark flaps on the trunk and main branches) were not present, the insect moved downward to the base of the tree and, often, out into the litter. Seventy percent of the large caterpillars were found in either the

bark flap niches or the litter. The rate of survival from day to day was much higher among the insects on the trees. Few, if any, survived excursions into the litter.

Their chief enemy was the white-footed mouse, *Peromyscus* sp. Thus this year's study, though not at all conclusive, strongly suggests that the interplay of niche availability, larval behavior, and mouse numbers is critical in the regulation of sparse populations of the gypsy moth.

Reciprocal crosses of the white-pine weevil, *Pissodes strobi*, and the northern pine weevil, *P. approximatus*, have been carried through as many as ten generations at our West Haven laboratory, with no appearance of sterility and no significant lessening of vitality. Since typical adults of the two species cannot be distinguished by eye with



A voracious predator of the gypsy moth under natural conditions, the white-footed deer mouse carefully removes the caterpillar's head capsule and peels back the hairy integument before eating the delectable body contents.

certainly, it is important to have some means of telling them apart and, if possible, discerning the hybrids.

Eight body characters were measured and four ratios of the major body dimensions were calculated for 100 adults each in the two species lines and the two reciprocal hybrid lines. The measurement means and two mean ratios differed significantly among the four groups. But none of these anatomical features were sufficient in themselves to assure proper placement of individual weevils in one population or the other. Multiple discriminant analyses are in progress to provide the best combination for positive identification.

As we learn more about the external anatomy and the behavioral characteristics of our primary pests, we become more curious about their internal organization — *why* they look and function as they do. Since the cell is the structural *and* functional unit of living things, the study of growth, differentiation, and all of the specialized functions that make a particular organism what it is logically begins at the cellular level. Many of our most intriguing problems in forest-insect research — the genetic make-up of the insects, the nature and specificity of their viruses, the neurological bases of behavior, resistance to insecticides, as examples — require some probing at this level. Such research is greatly facilitated if individual cells and tissues can be cultured apart from their progenitor.

The culture of insect tissues is extremely difficult and requires special techniques. In a special study at our West Haven laboratory, cells from gypsy moth testes have been maintained alive with some indication of outgrowths in a special medium, concentrated fetal calf serum. This work will be continued.

A cooperative aid study was initiated with the Department of Zoology and Entomology of the University of Connecticut, to differentiate certain weevils by serological and biochemical characterization of their extractable proteins. Preliminary work along this line was conducted at the West Haven laboratory. The particular insects under study are the white-pine weevil, northern pine weevil, deodar weevil, and pales weevil.

BIOTIC CONTROL

Insect pathology and the development of microbial agents for control of major pests were the primary foci of this project again this year.

Intensive tests were conducted with commercial preparations of the microbial insecticide *Bacillus thuringiensis* in the laboratory and field. Lethality and rate of action were determined with the gypsy moth and fall cankerworm as target insects. Comparative tests of "wild" crystalliferous bacilli showed them to be as lethal, or more so, than the *Bt* preparations. A number of adjuvants were screened: Pinolene 1674 and Pinolene 1773, derived from southern pine resins, proved good sticklers and had no adverse effect on spore viability or vegetative cell growth. Laboratory cultures of *Bt* were grown under controlled conditions on various media and the growth curves were plotted and analyzed. The elements necessary to maximize growth and to induce sporulation were determined, and valuable information was obtained as to the conditions optimal for spore and crystal production.

In cooperation with the Connecticut Park and Forest Commission, a helicopter spraying experiment with *Bt* was conducted in the Cockaponset State Forest against the gypsy moth. Two dosages of Thuricide 90 TS were applied at the rate of 2 gallons per acre when the caterpillars were in the

second and third stage of development. Gypsy moth numbers in the experimental areas were moderate to high. A parallel experiment was carried out in eastern New York in cooperation with the New York State Conservation Department and the New York State Museum and Science Service. The experimental conditions differed only in that the gypsy moth population was generally light to moderate and the predominant tree species were aspen and gray birch, while in the Connecticut areas oaks predominated.

The control effect in the Cockaponset plots treated with the heavier dosage (2 pints of Thuricide per 2 gallons of spray) was striking at first. A large number of caterpillars succumbed to disease from the *Bt*, and defoliation was very light. In contrast, the caterpillars in surrounding untreated stands appeared healthy and fed voraciously on the host trees. But the effects of treatment were not long-lasting, and enough insects escaped or recovered from the spray to cause heavy defoliation and to produce egg populations quite comparable to those in the untreated stands.

In the New York plots, the story was different. Here the heavier dosage effected a high degree of control—in terms both of foliage protection and reduction in gypsy moth populations. These plots received better coverage by the spray. This is the primary problem remaining in making *Bt* operational for gypsy moth control—efficient spray distribution and adequate deposit.

A pilot test of *Bt* was conducted against the fall cankerworm in cooperation with the Forest Insect and Disease Control Branch of U. S. Forest Service Region 7, the Pennsylvania Department of Forests and Waters, and the New Jersey Department of Agriculture. Four blocks in north-central Pennsylvania and two blocks in northern New Jersey were treated by air-

plane with 1, 2, and 4 pints of Thuricide 90 TS in 2 gallons of water per acre. The Pennsylvania stand type was northern hardwoods; the type in the New Jersey area was mixed oaks. A cooperative test of Sevin was conducted concurrently in the vicinity of the *Bt* blocks in Pennsylvania by the State's Department of Agriculture, and a large-scale control project against the cankerworm was conducted by the Pennsylvania Department of Forests and Waters with the assistance of Forest Pest Control funds and Forest Service entomologists. DDT was used in the control area.

Evaluation of the results of the pilot test of *Bt* has not been completed. But after-treatment sampling of the surviving females (which are wingless and crawl about on the tree trunks, where they can be trapped and counted) in all of the areas indicates that the heaviest dosage of Thuricide effected a degree of control comparable to that of Sevin. However, neither of these was as effective as DDT.

Fresh virus suspensions and powders were processed from diseased specimens of red-headed pine sawfly, European pine sawfly, linden looper, gypsy moth, and forest tent caterpillar. Disbursements for control or experimental purposes were made of the polyhedral viruses of the gypsy moth, European pine sawfly, and Virginia pine sawfly.

Two shipments of the anthocorid predator (*Elatophilus inimica*) of the red pine scale were sent to the Laboratory of Biological Control, Antibes, France, for study purposes. A related scale on pine in southern France is in outbreak form, and the researchers at the Antibes laboratory are searching diligently for an effective natural enemy to control the scale.

CHEMICAL CONTROL

Systemic insecticides appear to be an effective, if not the only, means of controlling certain forest insect pests. Cone and seed insects, needle and leaf miners, shoot and tip moths; and some scales and aphids have proved to be very hard to control by external broadcast sprays. Toxicants carried to the site of insect activity by the tree itself should be more efficient.

Tests were continued this year with Bidrin and certain adjuvants reputed to enhance absorption into the tree and subsequent translocation in the vascular system. Tested with Bidrin were DMSO (dimethyl sulfoxide), Ciba 200, and plain water, all formulations painted bandwise on the experimental trees 18 inches above the ground. Also, Bidrin in technical form (liquid) was implanted, using a special cartridge provided by the manufacturer. The test trees were white pines 3 to 5 inches at treatment height.

Results were evaluated by bioassay techniques: foliage from the upper crown levels was collected at intervals after treatment, macerated with agar in a feeding medium, and fed to replicated lots of the white-pine cone beetle. The implanted technical Bidrin was more potent than the diluted formulations painted on the trees shortly after treatment (3 days) and for an extended period (28 days). This implantation method may be more effective than the injection and frilling methods tested previously for control of the cone beetle.

INSECT IMPACT

This research project moved closer to official status when tentative approval of its aims and plans of work was given by our Washington Office. The stated objectives are to define, measure, predict, and evaluate the full impact of destructive insects on north-eastern forests and to provide guidelines for forest managers in making decisions regarding action against specific pests. The studies planned will fall into three phases characterized by the nature of the problems involved, the methodology required to obtain answers, and the training and experience of the researchers qualified to conduct the studies. The phases, or areas of study, are:

- Definition and description of the kinds and degrees of impact caused by insects to commercial tree species or species groups, and the development of methods for measuring the insect populations and the impact effects—in brief, what sorts of impact are involved and how can we best measure them?
- Determination of the factors or processes affecting variation in insect numbers and their impact effects, with regard both to differences in place and changes over time—what determines impact and how can it be modified?
- Integration of the biological and economic information obtained in the foregoing phases with management experience and cost analyses to develop optimum management strategy—putting the knowledge gained of insect impact into effective action.

The first detailed study will cover eastern white pine and its insect enemies.

FOREST DISEASES

OUR research program in forest diseases moved ahead this year in several ways. Major studies of the etiology of basal canker of white pine, the effects of chemical treatment on the development of discolorations and decays following increment boring, and the use of soil fumigants to control *Fomes annosus* are now in the final stages of investigation and analysis.

Related studies were begun to determine the impact of the basal canker disease on stand structure (using aerial photographic techniques and nonparametric measures of pertinent stand variables), and to assess certain factors influencing discoloration and decay after inoculation of living trees with Hymenomycetes (fungi known to cause decay). Problem analyses were completed on the two primary lines of research in our new program: (1) diebacks and declines, (2) discolorations and decays. Because they are most relevant now, these analyses are summarized briefly here.

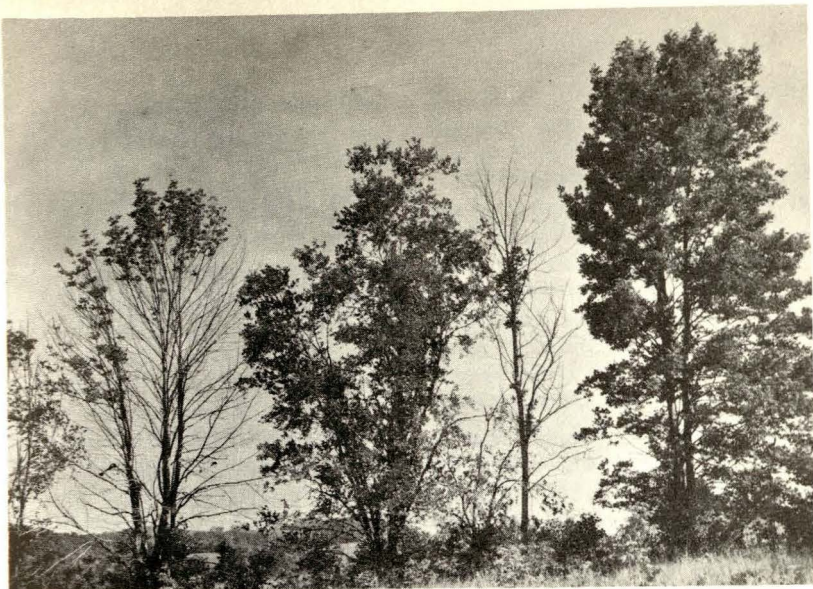
DIEBACKS & DECLINES

A significant number of commercial tree species and species groups have been affected on a large scale in recent years with severe deterioration and mortality. The most conspicuous of these have been birch dieback, ash dieback, oak decline and mortality, maple declines, needle blights of white pine, and sweetgum blight. Though comprehensive data are lacking on the biological and economic impacts of these diebacks and declines, manage-

ment experience and general observation indicate their importance very clearly.

The exact manner and rate at which these disease conditions develop differ, but all appear to be associated with environmental stresses. Generally involved, too, are organisms usually weakly pathogenic or secondary in action. The roles of the abiotic and biotic factors have been described primarily in qualitative terms. Research is sorely needed to elucidate the physiological mechanisms involved, the bases of susceptibility of trees to environmental stress, and the factors affecting pathogenicity of the associated organisms.

The studies required will fall logically into four phases, covering somewhat different subject matter fields: (1) epidemiology—the distribution of dieback-decline conditions (with respect to particular tree species) in time and place; (2) ecology—the interrelations among the identifiable and measurable abiotic and biotic elements, and their associations with the disease condition; (3) tree physiology—the physiological functions of the tree relevant to the disease condition under different degrees of stress; and (4) organism physiology—determination of the physiological functions and requirements of suspect organisms, their modes and rates of infection. Only with the integrated knowledge from all of these phases of research can we attempt to prevent or control diebacks and declines by environmental manipulations and/or direct treatments.



Typical symptoms of ash dieback affecting hedgerow trees in New York. Such scenes are common in many areas of New York, New England, and Pennsylvania.

DISCOLORATIONS & DECAYS

Discolorations and decays in living trees are primary determinants of timber quality and recoverable volume. Large losses in both the quality and quantity of timber from northeastern forests have resulted from these processes, especially as they have interacted with other destructive agents and forest-management practices.

Recent studies at our Station have shown that the discoloration and decay processes are intimately related and, moreover, that both involve complexes of organisms operating in a particular manner and sequence. These studies (of northern hardwoods) indicate that discoloration in the living tree can proceed alone, and it is a necessary precursor to the development of decay. The organisms involved in the discoloration process cause changes in the wood substrate that allow invasion by Hymenomycetes and other decay-causing organisms. This work emphasizes

the need for investigation of the beginning stages of the discoloration process, where bacteria and non-Hymenomycetes are active, and of the way in which decay begins.

The studies now planned comprise two phases in logical order: (1) ecology—description and definition of the discoloration and decay processes, their interrelations with each other and with measurable abiotic and biotic factors over a meaningful range of natural conditions (mathematical analyses will be utilized for both descriptive and predictive purposes); (2) physiology—determination of the physiological bases of establishment in and invasion of tree tissues by organisms, and the mechanisms of change in the wood substrate as the processes develop. As with the diebacks and declines, the information gathered in both phases must be integrated effectively to provide sound guidelines for forest managers to minimize losses from discolorations and decays in the living tree.

FOREST PRODUCTS MARKETING

FUNDS were received at the start of fiscal year 1966 to double the staff and program of the Station's marketing research project at our Forest Products Marketing Laboratory in Princeton, W. Va. At year end, the staff consisted of 18 scientists and 17 supporting people. Recruiting is in progress for five additional scientists, two technical staff men to work with the Assistant Director who functions as Chief of Laboratory, and for several additional technicians and clerical people.

Some revision of the Station's marketing research program was carried out during the past year. This was done in line with the nationwide reorientation of both marketing- and utilization-research objectives at the regional experiment stations. One change at Princeton involved the discontinuation of the subproject dealing with wood use in construction. Responsibility for this line of research for eastern softwoods and hardwoods now rests with the Southeastern Station at Asheville, N. C. A new line of research titled Industrial Opportunities was established at Princeton and is described in some detail later in this report.

Support of the marketing-research program by the wood industry and their cooperation in the conduct of studies has been outstanding during the past year. This enables us to accomplish things that would be otherwise impossible or at least far more difficult and time-consuming. At the same time, we are experiencing more and

more pressure by the different segments of the wood industry for research geared to their particular marketing problems. We fit as many of these problems into our program as possible, but find that 18 scientists can cover only a small fraction of the market investigations that are needed.

Half of the present scientific staff were recruited during the last 6 months of the year; yet progress has been good. At year end a total of 31 studies were under way, 8 reports had been published during the year, another 14 were submitted for publication, and 7 more were in preparation.

Brief discussions of some of the studies under way and the results of others are presented in the following pages for each of the four major lines of research at the Forest Products Marketing Laboratory.

PRIMARY FOREST PRODUCTS

Railway Crossties

The majority of people in the cross-tie industry believe that the wooden tie will never be seriously challenged by another material. They point out that thousands of patents have been issued for modifications in crosstie material and design, but that none has been adopted on a commercial scale. For example, of the nearly 1 billion ties now in use on America's railroads, less than 0.1 percent are of material other than wood. However, there are

strong indications that this condition is changing and that concrete may become a serious threat to the wooden tie.

During the past year, the Forest Products Marketing Laboratory has made an appraisal of factors affecting the railroad crosstie industry. This research was undertaken at the request of industry and had the support and cooperation of the Nation's leading railroads and tie-treating concerns. Two reports have been prepared for publication, one about the marketing aspects of tie production, and the other about potential ways for improving the manufacture and serviceability of ties. As a final step, we are preparing a detailed problem analysis so that future marketing and utilization research on ties at Princeton and at other research locations may be directed into the most productive channels.

The appraisal showed that wooden ties have been used successfully for more than 130 years in this country. During this time several notable improvements have been made so that an average service life of 30 years is not uncommon, even in main-line tracks. We found that there are many factors that affect ultimate tie life: composite strength of the wood; effectiveness of preservative treatment; rate of deterioration from decay, splits, plate cutting, and spike pulling; annual tonnage of traffic; train speed; and curvilinearity of track. These are all factors that affect crosstie serviceability.

Yet tie life was not found to be the most significant problem facing the tie industry. The problem is the lack of an available supply of wooden ties. Ties are scarce and the demand greatly exceeds the supply. This condition has existed for nearly 2 years. The trend may continue and become more acute in the years ahead, thereby creating a market for ties made from other materials — probably concrete. Last year several railroads were forced to install

prestressed concrete ties in new track because they were unable to buy enough wooden ties.

Why are ties scarce? There are dozens of reasons, but our analysis found that invariably they are all linked to the predominant problem of intermittent purchase. Some years the railroads want a large supply; other years they want only half as much. These fluctuations cause discontent and economic chaos in the tie industry all the way from the woods through the treating plants. Tie production cannot be regulated easily and rapidly. With each dip in demand, fewer tie mills remain; and with each rise in demand, tie prices must be increased to stimulate lagging production.

The problem analysis under preparation will cover these and other problems in detail and will recommend research needs. Preliminary results have triggered a study by the Princeton utilization project to determine the feasibility of producing and using trapezoidal ties. This study is discussed later.

Highway Guardrail Posts

Earlier studies at Princeton that were reported on last year showed the in-place cost of wooden guardrail posts to be substantially less than the cost of posts made from concrete or steel. Yet wooden guardrail posts are rarely used on new highway construction. Steel posts have captured almost the entire market where wood once predominated.

There is only one reason for the rapid switch from wood to steel: steel posts can be installed more rapidly. Wooden guardrail posts are satisfactory in terms of highway engineering standards and are competitive in price, but are slower to install. Each post must be set in an augered hole then back-filled and tamped. Steel posts are driven; therefore installation time is considerably less.



In an attempt to recapture the market for wooden highway guardrail posts, equipment has been designed to speed up post installation.

Recognizing the need for improved setting techniques for wooden posts, the Burke-Parsons-Bowlby Corporation arranged for the Arrow Manufacturing Company to develop a heavy-duty post driver. Our Princeton Laboratory assisted in the design and development of this machine. Several models have been tested on guardrail installations in West Virginia. Laboratory personnel who have participated in early field trials found that with this machine posts can be driven more rapidly than they can be set by augering and tamping.

There is little hope at this time that wooden guardrail posts can ever be installed as rapidly as steel posts: the difference in cross-sectional area between wood and steel posts gives a tremendous advantage to steel. There is hope, however, that wooden posts can be installed more rapidly than they are at present. A significant reduction in installation time should cause contractors to take another look at wood.

Several problems associated with driven wooden posts remain to be solved. None of these appear to be insurmountable. A study to evaluate

some of the factors involved in the driving of wooden posts will be carried out in the next few months in cooperation with the West Virginia Highway Department and one or more guardrail contractors.

PRIMARY WOOD-PRODUCT MANUFACTURES

Markets for lumber, veneer, cross-ties, and similar primary manufactured wood products were strong in 1965, and price levels were generally higher than in 1964. Substantial price increases were experienced in several species and thicknesses of lumber. However, unit production and distribution costs increased to such a degree that unit profits were essentially the same as in 1964.

During 1965, marketing research in this project area was concentrated on problems of quality control, cost reduction, and increased marketing efficiencies. Project personnel were involved in nine major studies during the year: three were completed, two were continued from 1964, and four new studies were initiated. In addition, assistance was given to the Forest Products Laboratory in two major Appalachia studies, and a \$100,000 cooperative-aid agreement was completed with Virginia Polytechnic Institute. The following is a summary of findings and comments on some of the major studies.

Evaluation of Air-Drying Practices

Final information is now available for the evaluation of air-drying practices for which preliminary information was given in last year's annual report. In this study, 26 shipments of air-dry red oak and yellow-poplar lumber were inspected at 18 sawmills in West Virginia, Virginia, Kentucky, and Tennessee to determine drying degrade losses and variation in moisture

content of lumber within individual shipments. A total of 329,000 board feet of 4/4- and 5/4-inch lumber from both winter and summer production was included in the study.

The study determined that degrade losses averaged \$13.95 per thousand board feet for red oak and only 23 cents per thousand board feet for yellow-poplar. One-half of the mills studied suffered degrade losses in red oak of less than 2 percent of lumber value, while the other half had losses exceeding 18 percent of lumber value. If the study results typify the entire Appalachian Region, the lumber industry could be losing approximately 30 million dollars annually in air-drying red oak alone. Many individual mills could increase net income from this species as much as \$12 per thousand board feet through improved drying practices.

As a result of this study, a research note was published to provide a guide to individual sawmill operators for quality control in air-drying operations. A paper on the study is being published for use by extension personnel in their training programs for industry.

An Economic Analysis of Forced-Air Drying of Appalachian Hardwoods

Air-drying of hardwoods is too slow to permit rapid response to changes in market requirements for different species and thicknesses of lumber. Therefore a major study is being conducted to determine the drying rates, drying costs, and degrade in forced-air drying as compared to air-drying of Appalachian hardwoods, particularly oak.

A low-temperature forced-air dryer was designed and constructed at our Princeton Laboratory in 1965. Drying tests are being conducted with lumber borrowed from nearby sawmills. Charges of matched lumber are dried in the dryer and in the adjacent air-

drying yard, permitting direct comparison of drying rates, costs, and degrade for the two methods.

Preliminary tests of the dryer indicate that 4/4 red oak lumber sawed in October can be dried to 25 percent moisture content in approximately 12 days as compared to 70 days in the conventional air-drying yard.

Air-Drying Costs and Returns

Air-drying is one means for extending markets for hardwood lumber, particularly for the smaller sawmills that harvest timber from small woodlands. Many of these mills are located on the fringes of market areas for the furniture plants and other lumber users; as a result the savings in freight due to weight losses in lumber from air-drying are large. However, air-drying of lumber is costly and the degrade from improper drying practices could offset the other advantages.

A study is under way to determine the costs of air-drying at commercial operations of different sizes, and to compare these costs with the increased returns from marketing air-dried lumber as compared to green lumber. This study may uncover some previously unknown factors that can be modified to improve the cost-benefit ratio of the air-drying process.

Factory Grade 3 Sawlogs as Raw Material for Appalachian Sawmills

Recent forest-survey reports show that more than two-thirds of the sawtimber volume in the Appalachian Region consists of grade 3 and lower quality logs. Although a portion of these logs will improve in quality with added growth, many of them will be harvested and utilized in their present condition.

A study is being made to determine the profitability of manufacturing

these logs into standard lumber. Five major species are included in the study: red oak, yellow-poplar, hard maple, cherry, and beech. Our data on production rates, production costs, product values, and profit levels for red oak logs at a conventional circular sawmill show that grade 3 logs are sawed at near the break-even point and are not a suitable source of raw material for most of the present types of sawmill units (table 3).

Results of this study will be correlated with those of another study to determine the economics of converting low-grade hardwood bolts directly into specific products such as pallet stock or dimension. New conversion systems will be involved in the process.

The Supply and Demand for Yellow-Poplar

Because of its excellent wood properties, yellow-poplar is a valuable and versatile hardwood. It has a number of alternate uses; some are relatively new. They include the increase in demand for yellow-poplar pulpwood in the South; the increased use of yellow-poplar lumber for exposed wood furniture parts; and the use of yellow-poplar for particleboard chips. In contrast to these new uses, some traditional uses for yellow-poplar are being taken over by other products. The increased use of particleboard as a replacement for yellow-poplar lumber for core-stock material in furniture, fixtures, and cabinets is one relatively recent change in this direction.

If we are sure about these changes in present and future uses of this important hardwood species, what can be forecast about future markets for yellow-poplar? Will future supplies be sufficient in quantity and quality to meet future needs? Or will there be a need to develop new markets for this species? Answers to these questions can be vital to forest managers, timber producers, and processors as they plan

Table 3. — *Comparison of production rates, product values, and profit margins for factory-grade 1, 2, and 3 red oak sawlogs*

Log grade	Production rate, bd. ft./hr., mill tally	Average lumber value per 1,000 bd. ft. mill tally	Production cost ¹ per 1,000 bd. ft. mill tally	Actual log cost per 1,000 bd. ft. mill tally	Profit per 1,000 bd. ft. mill tally
1	1,440	\$130.00	\$38.20	\$70.00	\$21.80
2	1,350	93.60	40.70	43.50	9.40
3	1,080	73.20	50.90	21.80	.50

¹ Includes all fixed and variable costs for milling, yarding, drying, grading, sorting, and preparing lumber for shipment f.o.b. yard. Does not include log cost.

their operations and marketing for the future.

To answer these questions and to develop a better understanding of the place of yellow-poplar in the market place, we have undertaken an analysis to estimate demands for yellow-poplar products during the next 10 years, and to relate these demands to timber supply.

SECONDARY WOOD-PRODUCT MANUFACTURES

The staff of the division has increased during the year from two scientists to six, and two positions remain unfilled. As a result, several new studies have been started. The principal products undergoing investigation during the past year are flooring, pallets, hardwood dimension, and beverage cases. We anticipate concentrating on these products during 1966.

Wooden Flooring

Our study on the comparative maintenance costs of residential floors is nearing completion. During the year, data on the comparative maintenance of wood and other types of floor coverings were collected in New York

City, Chicago, St. Louis, Denver, Los Angeles, Houston, Atlanta, and Washington, D. C. Data were collected in Boston in 1964 to test the survey questionnaire. All data have now been programmed for computer analysis. The portion of the study covering housewives' preferences for floor covering has been analyzed, and a summary of the results is presented in table 4.

Early in the year, the data from the pre-sample in Boston were analyzed and results were published. This report was very favorably received by the industry and was employed to convince the Federal Housing Administration, the New York City Rent and Rehabilitation Administration, and others to specify oak strip flooring in the 39-building pilot project for rehabilitation of the 43,000 "old law" apartment buildings in the city. This project represents a potential market for about 470 million board feet of flooring—equal to approximately 50 percent of present total annual production.

Another study in the general area of merchandising, distributing, and installing hardwood flooring in single-family dwellings has been initiated. The purpose of this research is to de-

Table 4. — *Preferences of housewives for flooring in new housing in the Northeast¹ and nationally, in percent*

Flooring type	Northeast			Nationally ²		
	Living room	Dining room	Bed-room	Living room	Dining room	Bed-room
Hardwood flooring	50.98	43.38	55.40	38.76	39.83	43.66
Oak strip	33.99	31.62	43.24	29.38	30.38	35.77
Oak parquet	16.99	11.76	12.16	9.38	9.45	7.89
Carpet	41.83	26.47	33.11	55.58	37.50	48.46
Composition tile	3.92	24.26	7.44	3.86	19.19	5.48
Asphalt tile	1.31	4.41	2.03	1.10	4.22	1.41
Vinyl asbestos tile	2.61	19.85	5.41	2.76	14.97	4.08
Cork tile	1.96	2.21	2.03	.41	.58	.56
Other	1.31	3.68	2.03	1.38	2.91	1.83

¹ Responses for the Northeast are a combination of those obtained in New York and Boston, which are believed to be representative of the region — although this was specifically tested.

² National response are all those obtained in Boston, New York, Chicago, St. Louis, Denver, Los Angeles, Houston, Atlanta, and Washington, D. C.

termine factors or problems in these areas that are limiting the markets for hardwood flooring and to develop recommendations for their solution.

Wooden Pallets

A series of studies has been started to analyze the markets for wooden pallets. One study, in the steel industry, has been completed; and the findings were rather encouraging. The study revealed that the steel industry is relatively well satisfied with the performance of wooden pallets. Pallet purchases by the major steel mills are normally based on a very close coordination with a nearby pallet manufacturer who specializes in producing pallets for the industry. The demand for hardwood pallets in the steel industry is expected to increase from about 81 million board feet in 1964 to more than 100 million by 1970.

A study to analyze the Department of Defense's requirements for wooden pallets has progressed through the pre-

liminary field sampling and the study-plan stage. Findings to date indicate that inconsistencies exist in military specifications relative to commercial specifications, that the market is unpredictable because of purchasing schedules and policies, and that many pallet manufacturers prefer not to manufacture for this market because of these and other factors.

The study plan and preliminary field sampling have also been completed for a study of the pallet market in the malt-liquor brewing industry. Findings to date indicate that: pallet-use policies and practices vary widely between companies; pallets in many instances are not employed as a unitizing system throughout the distribution channels; the size and specifications for pallets have not been standardized in the brewing industry; and there is a good potential for increased pallet markets in the 100 or more concerns making up the brewing industry.

A series of cooperative studies are planned with Better Management Serv-

ices to determine ways of increasing the market for wooden pallets in the food industry. A master memorandum of understanding has been drawn up and the first cooperative agreement has been completed, for evaluating the comparative performance of wood pallets, slip sheets, clamp trucks, and manual handling. These studies have been coordinated with the research programs of the Wholesaling and Retailing Research Branch of the Transportation and Facilities Research Division of the Agriculture Research Service, the National Wooden Pallet Manufacturers Association, and the Food Department of the University of Massachusetts.

Work is also in progress on another study with Better Management Services to determine the opportunities for the greater use of wooden pallets in the handling of frozen foods. A third study is being prepared to evaluate the physical performance of different types and qualities of wooden pallets under actual use conditions.

Hardwood Dimension

A study plan and preliminary field sampling have been completed for a problem analysis of the hardwood dimension industry. Findings to date show — as were expected — that this industry is tied closely to the furniture industry, the major market for dimension material of all types.

However, we found that fewer than one-half of the furniture manufacturers purchase dimension material, and many of these users purchase dimension only as an adjunct to their own mill production. There also appear to be good opportunities for increased efficiency in the manufacture and utilization of partially manufactured parts (dimension) as a means of improving the competitive position and market for hardwood lumber.

Shipping Containers

Preliminary field sampling and a study plan have been completed for determining and analyzing the factors that affect the decision by bottlers of carbonated beverages to buy either wooden or plastic cases. The market for soft-drink cases is expected to decline about 12 percent from 1964 to 1970 due to increased bulk shipments and the use of non-returnable bottles, cans, and other containers. In addition, the introduction of plastic cases in recent years now threatens to virtually eliminate the market for wooden soft-drink cases.

Present information indicates that neither the bottling companies nor the manufacturers of wooden cases have substantive data on the basis of this trend. Our current study will attempt to determine how the producers of wooden cases can modify their product or service to hold their current dominance in this market.

INDUSTRIAL OPPORTUNITIES

A number of social and economic factors are evident in the Appalachian Region and in the Nation's economy which suggest increased opportunities for an expansion of the Appalachian Region's forest product industry. One line of research was accordingly designed to identify and evaluate opportunities — especially with regards to marketing activities — for increasing the importance of the wood industry in the Appalachian area. Although the project is in its formative stage, progress has been made. A review of several of the studies under this activity follows.

Forest Cooperatives

The research on forest cooperatives reported in last year's report has been completed except for some manuscript



Log quality should be determined in the mill yard rather than in the woods or on a truck. Here the logs can be spread out so surface and end defects can be easily seen.

revision. The investigation found that for 50 years cooperative enterprise has been tried as a means for improving the production practices and income of small-scale woodland owners. We also found that most of the forest-based cooperatives established before 1961 went out of business because of inadequate management, inadequate capital for initial and working investment, insufficient interest and support by members, and the lack of an adequate volume of business.

Past experience has provided present-day proponents of cooperatives with at least three essential actions to perform before organizing: (1) establish a set of guidelines for evaluating the cooperative's potential; (2) make an objective feasibility study; and (3) develop a comprehensive pre-organiza-

tion plan for subsequent organization and operation. Three reports on forest cooperatives are now being prepared for publication. They include an annotated bibliography, an article discussing the study results, and a set of guidelines for establishing forest-based cooperatives.

Evaluation of New Products

Results of a preliminary analysis covering the production and market potential of a new type of wooden wall paneling developed at the U. S. Forest Products Laboratory were discouraging from an economic standpoint. This proposed product utilizes low-grade hardwood logs and is unique in both its structure and esthetic characteristics. Following the preliminary

analysis, significant modifications in flitch thickness, structural design, and packaging methods have been made by the Madison Laboratory. These improvements have led to the undertaking of a new evaluation of the market potential of this paneling material. Results will be available early in 1966.

Another analysis is under way to assess the potential cost of production and market success of a sound-reducing ceiling tile made from hardwood chips. Both the esthetic and sound-deadening properties of the tile are believed to be acceptable for its intended uses. Factors yet to be ascertained are production costs, competitive position as a substitute for acoustical tile now on the market, and the product's potential value to the consumer.

An economic comparison of the "slice-wood" process developed at the Forest Products Laboratory for converting logs into boards — versus conventional sawing — is under way. The "slice-wood" process is a method to lower log breakdown cost by increasing the speed of conversion, eliminating kerf loss, reducing manipulations of the log on the carriage, and producing lumber or flitches of designated thicknesses that can be fabricated into products of different sizes and forms. One of the important objectives of the

analysis will be to develop information about the limits that must be placed on the initial installation cost of the slicing machine.

Market Improvement

Our initial study in this field is designed to develop and test empirical techniques for forecasting the volume and characteristics of Christmas tree demand within specific urban markets. Studies have shown that a large portion of trees made available by retailers in certain markets remain unsold, whereas insufficient number of trees are available in other market places. In both situations economic losses are often sustained by producers, vendors, and consumers.

We believe that the principal cause of such surpluses and deficits is a combination of limited market information, lack of organization among producers and vendors, and absence of reliable information necessary for decisions on planting, harvesting, and marketing. Our Princeton Laboratory will endeavor to determine means to better correlate the production and marketing of Christmas trees with the public need. The research will also determine the opportunities of increasing the production of Christmas trees in the Appalachian area.

TIMBER QUALITY

TWO additional men were added late in the year to our northern softwood log-and-tree-grade project in Upper Darby. Fred Dorr was transferred from Timber Management, Region 7; and Dave Sonderman moved over from our Forest Survey unit. The project is now a 3½ man-year effort. Accomplishments during 1965 included the following activities.

Data from all eight white pine log-grade yield studies were re-edited, including the application of several new modified grading systems. Grade-yield data were repunched for all eight studies and, except for the last three studies, have been transferred to tape for machine processing at the New Haven Biometrics Center. The data cover a total of 2,900 logs and 500 trees. Processing of data should start early in 1966.

All field data from the Minnesota red and jack pine log-and-tree-grade studies have been edited and are now ready for punching. Punching has been deferred until processing of the white pine data is completed. Preliminary examination of data indicates that the inland Douglas-fir tree/log grades (with slight modification) will be adequate for both red and jack pines.

A study plan covering field procedures for a series of eastern hemlock log-and-tree-grade studies has been developed and approved. Arrangements have been made with the Pennsylvania Forestry Service and the National Forest Administration for cooperation in the first study, which is planned to begin in northern Pennsylvania early in 1966.

Softwood log-grade-project person-

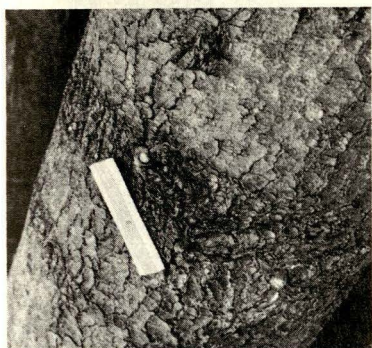
nel participated in a Canadian white pine log-grade study at Waba, Ontario, for the purpose of standardizing study procedures. As was expected, comparisons of lumber-grade recovery as it is now graded by the rules used by the Northeastern Lumber Manufacturer's Association and the Canadian Lumberman's Association pointed out some highly significant differences. A report has been prepared for presentation at the next annual meeting of the Canadian Lumberman's Association, at which time representatives of both the Northeastern Lumber Manufacturer's Association and the Northern Hardwood and Pine Manufacturer's Association (Lake States) have been invited to discuss the need for standardization of grades among the several associations.

The revised edition of our booklet, *A Guide to Hardwood Log Grading*, was released in early May. This publication has been a best-seller: the first edition of 7,000 copies was exhausted in less than 2 years. A rough draft of a proposed publication, *Identification and Evaluation of Grade Defects in Eastern White Pine Logs and Trees*, has been completed. Publication will be deferred until final approval of the proposed white pine log grades.

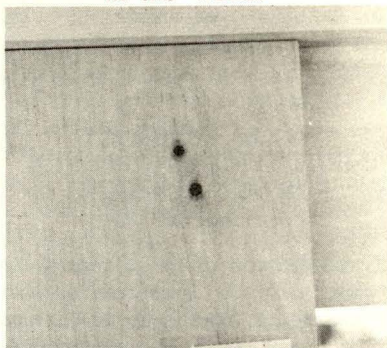
Log-grade-project personnel participated in the third and final grade-yield study for pruned white pine in cooperation with New York State College of Forestry at the Pack Demonstration Forest at Warrensburg, N. Y. A publication dealing with the economics of thinning white pine is being prepared jointly by personnel of the Pack Forest and the Station.

Grade defects in white pine logs are numerous and of many types.

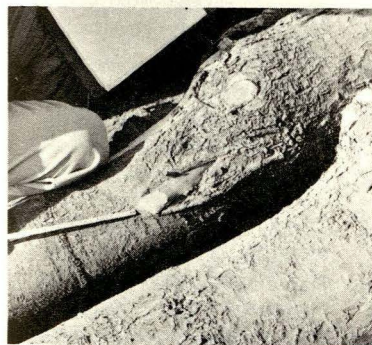
Small pin knots . . .



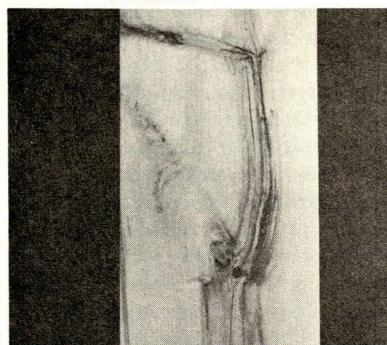
. . . result in blemishes in the wood.



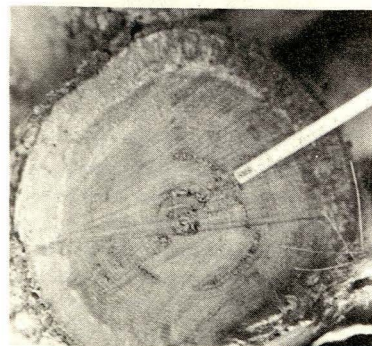
Crooks from weevil injury . . .



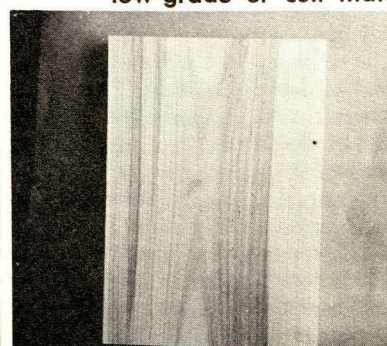
. . . result in coarse, knotty, cross-grain, low-grade lumber.



Red ring rot infection . . .



. . . results in rot-streaked low-grade or cull material.



UTILIZATION RESEARCH

WOOD PRODUCT IMPROVEMENT PROJECT FOR APPALACHIA

Princeton, W. Va.

IN a reflection of the changing nature of the forest-products-research program of the Forest Service, a new wood product improvement project was established in August at our Princeton Laboratory. The initial staff consists of three scientists and two supporting personnel. The major emphasis of the project is on improvement in the utilization of Appalachian hardwoods in manufactured wood products.

Most of the project research will be done in our Methods Testing Plant. This laboratory-workshop, with a floor area of 10,000 square feet, will contain a processing line, a general wood-working area, and reserved floor space for temporary studies. With these facilities, it will be possible to convert logs into different types of finished products. The processing line will initially contain a primary breakdown device utilizing a band saw, a straight-line rip saw, a trim saw, and a four-surface planer. Facilities for lumber drying and humidity rooms will be added later.

The project will conduct research in four interdependent areas. One is the development of product standards and requirements needed to maintain or improve the market position of existing wood products. A second is the determination of new and more economical systems for the conversion of lower quality hardwood logs into lumber and also directly into such products as pallet stock or railroad

ties. A third line of research involves the development of technological information for the improvement of manufactured hardwood products or the development of new products. The fourth area of research is concerned with special market-oriented problems of special interest and importance to producers and users of hardwood products in the Northeastern United States.

Two major studies are now in progress. The first of these involves the development of a system for converting low-grade red oak bolts—not logs—directly into ready-to-use pallet material.

In this system, logs will be bucked into 64-, 52-, or 40-inch bolts. The bolts will then be sawed into 1- or 2-inch boards. These in turn will then be ripped into 4- or 6-inch widths. After ripping, each board will be trimmed or cross-cut (depending on original bolt length) into one or more of seven specified lengths. Planing of these cut-to-size pallet parts will complete the process—although an optional drying step may be added. By restricting this study to the pallet lumber sizes mentioned, 17 of 21 warehouse pallet types specified by the American Standards Association can be built.

A key step in the pallet-systems development is the determination, through the use of computers, of optimum log-bucking and/or bolt-sawing procedures for the lower grades of raw material. In this portion of the study, 150 bolts, 64 inches long and of varying diameters, will be sawed into 1-inch thick boards. Defects will be recorded on board diagram analogs

and converted into digital form for computer use. A computer program will be written, allowing the hypothetical rebuilding and resawing (4 additional ways) of the original bolts. Many more tests can be made with the same data if needed. An analysis of variance will be run to determine whether significant differences exist among the four hypothetical procedures. If no difference exists, it is safe to assume that the bolts can be sawed through and through without loss in product value.

The second study under way involves an exploratory investigation of the effects of air-seasoning and forced-air drying on the occurrence of checks and splits in large trapezoidal-shaped crossties. A larger tie of uniform size and shape capable of supporting the heavier and faster trains of the future is considered necessary to insure this \$100 million per year market for preservative-treated wood.

A concrete tie suitable for this need is already in use on several major railroads. However, it is not known whether the seasoning problems that affect smaller wooden ties will prohibit the manufacture of larger solid-wood ties. End-coating and end-drilling treatment will be used in attempts to control the severity and frequency of defect occurrence. If promising results are obtained, large-scale cooperative studies with tie producers, and in-service tests, are anticipated.

WOOD PRODUCT IMPROVEMENT PROJECT FOR NEW ENGLAND

Upper Darby, Pa.

This project, formerly titled utilization improvement, was revised in July 1965 to permit a more direct research attack on the problems related to manufactured hardwood products and other utilization research peculiar to New England. Technical service to industry, distribution of research data

from outside sources, and the liaison functions formerly done by the project will be carried on by the utilization branch of the State and Private Forestry Area Office in Upper Darby. This branch is now adding to its staff and developing its program. The transfer of these activities from research to S&PF will be gradual.

Our initial study on the outdoor storage of northern hardwood chips has been completed, and the results will be presented at the national meeting of the Technical Association of the Pulp and Paper Industries in February 1966, and will be published shortly thereafter. The results show that the temperature rise is extreme during the first 10 to 20 days of chip storage and generally decreases thereafter. The moisture of the wood stored in chip form drops slowly during the first 4 months and then rises slightly towards the end of the storage period as the temperature declines. The relationship of the temperature in certain parts of the pile near the lower outside edge to the outdoor temperature conditions indicates that there is a chimney-like flow of air through the entire storage pile.

Chemical analyses of the main constituents of the wood chips showed that no appreciable changes in wood quality took place. In view of this it was assumed that color changes occurring in the wood during storage must be attributed to some factors other than wood deterioration.

To attempt some control over these other changes, a second study was begun in May 1965, in which 85 chemically treated samples were placed in the chip-storage pile. The chemicals used were generally free radical traps and preservative materials. Half of the chemically treated samples were removed from the chip pile at the end of 1 month and the remainder after 6 months. All of the samples will be formed into groundwood paper sheets and the color changes will be

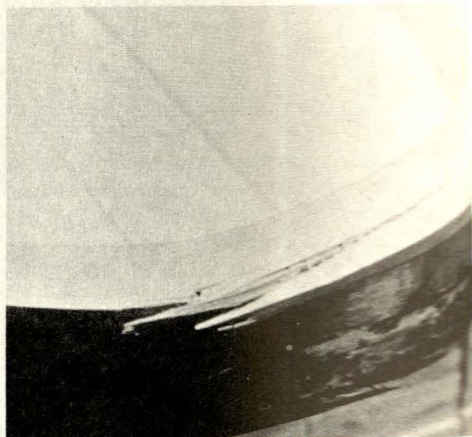
determined by measurement. It is hoped that the chemical treatments may control color changes of the chips that are thought to be caused by the extreme heat rise in the pile, or possibly may control the heat changes directly. A report on this second study is expected to be published in 1966.

The growing market for furniture items containing bent wood parts has led to an increase in inquiries about ways of improving the bending process. The satisfaction of this need has been complicated by the shortage of material of a grade usually used in wood bending, and the differences in bending quality of substitute species.

A review of the status of the wood-bending industry, including an evaluation of several of the new advances in wood bending, was carried out to determine whether further research is needed on the problem. A summary of the results was reported at a meeting of the Southern Furniture Manufacturer's Association and was later published by the association. From industry response to this report, and in view of the fact that much remains

to be learned about plasticizing methods and properties of wood as they apply to bending, it appears that further project research will be done in this field.

Project personnel continued to be active in timber-quality research. Assistance was given to the hardwood log-grade project on log-and-tree-grade



Bending defects occur despite good bending practices.



A typical bending operation. Steaming retorts can be seen at the left, and curved hot-plate presses at the right.

studies in the Northeast — two on red maple, four on chestnut oak, and one on yellow birch. The data are now being analyzed by the hardwood log-and-tree-grade project at Columbus, Ohio, and will shortly appear as supplementary data in the overall Forest Products Laboratory report on log-and-tree-grade studies.

We also conducted a variety of studies of limited regional interest and scope, often in cooperation with local industry. In one of these studies an analysis was made of the handling of ladder-rail stock in relation to the occurrence of failures in these rails. A method for detecting the inherent compression failures that had previously escaped notice was eventually

recommended to this company as a means of correcting their problem.

A second study to determine the feasibility of establishing a new softwood plywood plant within the region was done in cooperation with a group of interested wood industries. We conducted research on several utilization aspects that, all in all, indicated that the establishment of such an industry is feasible in the Northeast, but at the moment lacks sponsorship. Other short-term unpublished studies were carried out on the development of shake in birch bolts stored under water sprays, the feasibility of high-frequency drying of specific products, and the correction of adhesive problems in a specialty hardwood veneer-product plant.

FOREST ENGINEERING

OUR forest engineering project, located at West Virginia University, received sufficient funds under the Appalachian Development Act to employ project scientists and supporting personnel and to enter into a number of cooperative-aid agreements covering engineering-research projects by staff people at the University. Prior to the availability of this money, the project staffing had consisted of the project leader and one secretary.

The staff now includes the project leader, three engineers, two full-time and five part-time engineering aides, and two clerical people. Another 48 university personnel, including student assistants, are working part-time on cooperative-aid projects funded by the forest engineering project.

Following the preparation of a detailed review and evaluation of timber harvesting and related problems in the Appalachian area, three major problem areas were selected for study by the forest engineering project: (1) improvement of harvesting methods, with special reference to Appalachian hardwoods; (2) improvement of transport and materials-handling of primary forest products and on-site manufactures; and (3) improvement of methods and systems of utilizing low-grade primary forest products. Detailed problem analyses that included a listing and description of the research needs were prepared for each problem area.

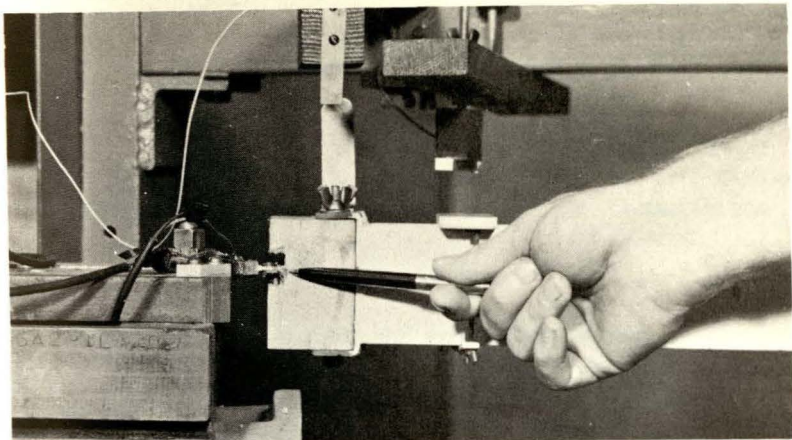
SYSTEM ANALYSES

High priority was given to initiation of a study that involves a systems analysis of present-day logging meth-

ods in the mountainous Appalachian area. The purpose is to determine ways that engineering research can improve the harvesting and transporting of primary wood products. One of the phases of the work involved the development of mathematical models for estimating harvesting costs when rubber-tired skidders are used.

Formulae were developed in this work for estimating the costs of felling and limbing, bunching, and skidding for three classes of species: (1) oaks and hickories, (2) red and sugar maples and beech, and (3) miscellaneous. Data were based on diameter classes for each species group. The mathematical models can be used as a basis for computing practical curves and tables to aid loggers in estimating costs when rubber-tired wheeled skidders are used. The current work is not considered to be applicable to all possible conditions, but is considered to be a significant step towards better understanding of harvesting costs.

In conjunction with the above work, an analysis was made of the external characteristics of wheeled skidders in relation to the type of terrain they will negotiate and the loads they can move under different conditions. A system has also been devised for the classification of terrain into categories that can be used for comparing different types of harvesting machines. Preliminary work has also begun on the development of a similar standard classification for measuring work output. At least 23 technical papers are planned for publication on results of the system analysis research during 1966.



Measuring the cutting forces of a chain-saw tooth. The wood sample is mounted on a rotating beam so that it will pass by the tooth at the desired cutting rate.

COOPERATIVE RESEARCH

Nine cooperative-aid studies were planned and got under way during the year between the Station and West Virginia University. These studies, which utilize the special talents available within the several engineering staffs at the University, are as follows:

1. A preliminary investigation into the cutting action of chain-saw teeth. This study has already been developed to the point where for the first time the forces in all three planes acting upon a chain-saw tooth cutting across grain in wood have been isolated and measured.

2. An engineering research study to determine the feasibility of utilizing gas generators as sources of power for portable logging tools.

3. A study to investigate the possibility of adapting revolutionary new internal combustion engines as power sources, as well as new concepts of power-generating devices.

4. A study to identify and objectively describe hydrologic environmental conditions that affect operating conditions in the forest.

5. A theoretical study of the practicability of utilizing belt conveyors and other mechanical conveying devices for moving material from forest to mill.

6. A preliminary theoretical study of recent advances in explosives, slow-burning propellants, combination reactive fuels, and more exotic fuels to determine potential feasibility for adaptation to forestry operations. Consideration is being given to energy available, energy release rates, and probable safety factors.

7. A machine-data problem study directed toward accumulating in tabular and other suitable form part of the data being assembled by the Forest Service research personnel at Morgantown and the University. It will speed up the accumulation of material that can be published as an immediate aid to loggers.

8. A preliminary study of the modification of the Zimmerman process for producing power for forestry operations.

9. A study of the feasibility of utilizing wood as a source of power.

PUBLICATIONS

in 1964 by staff members and cooperators of the Northeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture.

*Bjorkbom, John C., David A. Marquis, and Frank E. Cunningham.

1965. The variability of paper birch seed production, dispersal, and germination. U. S. Forest Serv. Res. Paper NE-41, 8 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

A summary of existing seed-crop information revealed that medium or better crops occur about 50 percent of the time. In northern New England, up to 96 percent of the paper birch seed crop was dispersed by the end of October. Best germination coincided with years of greatest seed production. Seed weight was greatest during good seed years.

Blum, Barton M., and Stanley M. Filip.

1965. An on-the-ground demonstration of northern hardwood timber management. N. H. Forest Notes 86: 16-19, illus.

Describes four plots set up on the Bartlett Experimental Forest in New Hampshire to demonstrate forest-management practices applicable to the northern hardwood region.

Church, Thomas W. Jr.

1965. Railroad crossties: opportunities for improving the manufacture and serviceability. S. Lumberman 211 (2632): 120-123, illus.

The wooden tie has maintained its monopolistic position since the advent of American railroading. Tie life has been extended through preservative treatment, better seasoning, and improved mechanical serviceability. Yet the future of the wooden tie may be threatened by competing materials such as concrete. Research is needed to insure the manufacture of a better wooden tie at a reasonable cost.

Cobb, F. W. Jr., and R. A. Schmidt.

1964. Duration of susceptibility of eastern white pine stumps to *Fomes annosus*. Phytopathol. 54: 1216-1218.

Reports the length of time that stumps of 50-year-old *Pinus strobus* L. remained susceptible to invasion by *Fomes annosus* (Fr.) Karst. The stump surfaces were highly susceptible for only 1 to 3 days after cutting.

Cobb, F. W. Jr., F. A. Wood, and R. A. Schmidt.

1965. Occurrence of *Ceratocystis fagacearum* in wounds on red and chestnut oaks. Phytopathol. 55: 179-182.

Reports the occurrence of the oak wilt fungus in wounds made on diseased red and chestnut oaks in Pennsylvania. Spores of the fungus were found in the

* Copies or reprints available.

wounds on red oaks in all stages of wilt, but were most abundant at the mat-production stage. The occurrence of the fungus in the wounds on diseased chestnut oaks was rare and not different statistically from occurrence in wounds on healthy trees.

*Cosenza, Benjamin J., and Franklin B. Lewis.

1965. Occurrence of motile, pigmented streptococci in Lepidopterous and Hymenopterous larvae. *J. Invert. Pathol.* 7: 86-91, illus.

Forty isolates of motile, yellow-pigmented streptococci were obtained from the gypsy moth, red-headed pine sawfly, and a subtropical moth. All isolates proved to be variants of *Streptococcus faecalis*, the first recovery of this motile, pigmented type reported on insects.

Cunningham, Frank E.

1965. Some factors that may influence germination, survival and growth of sugar maple. In *Direct seeding in the Northeast.. Univ. Mass. Coll. Agr. Exp. Sta. Symp. Proc.*: 45-47, illus.

In studies of sugar maple seeding, mineral soil seedbeds free from grass and weeds provided conditions favorable for germination, and shade ranging from 33 to 67 percent seemed to benefit seedling growth and survival.

*Cunningham, Frank E., and Richard J. Peterson.

1965. Air-layering sugar maple.

U. S. Forest Serv. Res. Paper NE-42, 16 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Describes procedures and methods used to root branches of sugar maple trees by air-layering. Rooting response varied among individual trees, times of year when treatments were applied, width of girdle used in wounding branches, and treatment position on the branch. Although mortality of the rooted cuttings over the first winter was high, survivors grew well with little subsequent mortality.

*Cunningham, Frank E., and Daniel W. Sowers.

1965. Simazine no substitute for cultivation in hybrid poplar plantations.

U. S. Forest Serv. Tree Planters' Notes 70: 21-26, illus.

Simazine at 1, 2, 4, and 6 pounds per acre was tested for its efficacy in controlling weeds when applied after planting hybrid poplar cuttings on a plowed site. Height growth and survival were significantly better on the control plots where hand cultivation was used than on any of the simazine plots.

*Cuppert, D. G.

1965. A practical method of in-plant evaluation of seasoning degrade.

Forest Prod. J. 15(8): 341-342.

The reduction in lumber quality due to seasoning degrade often exceeds the acceptable limits of 2 percent for the more important Appalachian hardwood species. Techniques are described that will enable lumbermen to evaluate the economic loss from seasoning degrade and to take action to minimize such losses in the future.

*Cuppert, D. G.

1965. How to determine seasoning degrade losses in sawmill lumberyards.

U. S. Forest Serv. Res. Note NE-32, 7 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Describes the important types of lumber degrade found at Appalachian sawmills

and lists the manufacturing practices responsible for such losses. Outlines procedures for determining seasoning degrade.

Davis, Grant (ed).

1965. **A guide for revegetating bituminous strip-mine spoils in Pennsylvania.** Res. Comm. on Coal Mine Spoil Revegetation in Pennsylvania. 46 pp., illus.

This guide brings together in one publication the most up-to-date information available about the revegetation of bituminous mine spoils. It includes sections on legislation related to strip mining, the characteristics and classification of spoils, revegetation planning, and reclamation for woodland, agriculture, wildlife, and recreational uses.

*Diller, Jesse D.

1965. **Chestnut blight.**

U. S. Dep. Agr. Forest Pest Leaflet 94. 7 pp., illus.

Describes the symptoms, hosts, and fungus responsible for what is generally believed to be the most destructive forest disease known. The past and present research programs to produce trees resistant to the disease are reviewed, and the present status of research is discussed.

Diller, Jesse D.

1965. **Soil covers protect basementless houses from wood decay.**

Int. Symp. on Humidity and Moisture 41: 340-348, illus.

Describes the results of tests, begun in 1942, using soil covers in the crawl spaces of basementless houses to reduce relative humidity and condensation and thus prevent decay. The tests indicated that several materials, including ordinary roofing paper, can effectively reduce the relative humidity and thereby prevent the growth of wood-rotting fungi.

*Diller, Jesse D., and Russell B. Clapper.

1965. **A progress report on attempts to bring back the chestnut tree in the eastern United States, 1954-1964.** J. Forestry 63: 186-188.

Outlines the limited progress made in the past 10 years in the research program of the U. S. Department of Agriculture. No native American chestnut has proved to be resistant; one Asiatic tree was found to be better than all others with respect to blight resistance, growth, form and nut production; and a few hybrids, especially the "Clapper chestnut", appear promising.

*Diller, Jesse D., Russell B. Clapper, and Richard A. Jaynes.

1965. **Cooperative test plots produce some promising Chinese and hybrid chestnut trees.** U. S. Forest Serv. Res. Note NE-25, 8 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

Presents, in terms of height and diameter growth of residual trees, the results of experimental test plantings of Chinese and hybrid chestnut trees. The location of the plots, the date of planting, and the pedigree of the hybrids are summarized.

*Federer, C. Anthony.

1965. **Sustained winter streamflow from groundmelt.**

U. S. Forest Serv. Res. Note NE-41, 4 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Measurements of soil temperature profiles and estimates of soil thermal conductivity led to the conclusion that groundmelt of snow can account for sustained winter streamflows. Heat conducted from within the soil to the bottom

of the snowpack causes the snow to melt even though air temperatures may be continuously below 10° F.

Federer, C. Anthony, and C. B. Tanner.

1965. **Artificial light for plant growth.**

Agron. J. 57: 314-315.

The spectral distributions of cool white fluorescent and Sylvania Gro-Lux light sources show that a 50-50 combination of the two approximates sunlight better than either source alone.

Federer, C. Anthony, and C. B. Tanner.

1965. **A simple integrating pyranometer for measuring daily solar radiation.**

J. Geophys. Res. 70: 2301-2306.

An inexpensive instrument was designed to integrate daily solar radiation flux density, using two or more silicon solar cells and a Curtis mercury integrator.

*Fenton, R. H.

1965. **Root grafts and translocation of 2,4,5-T in young sweetgum stands.**

J. Forestry 63: 17-18.

Backflash mortality of untreated trees was observed in New Jersey sweetgum stands where 2,4,5-T had been applied with injectors in experimental thinnings. Translocation of the herbicide from treated to untreated trees through root grafts was verified by examination. Treated stems should be at least 1½ feet from the crop trees to prevent this damage.

*Fenton, R. H., and A. R. Bond.

1965. **Pre-commercial thinning not recommended for Virginia pine stands in southern Maryland.** U. S. Forest Serv. Res. Note NE-40, 7 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Pre-commercial thinnings in 7- and 17-year-old Virginia pine stands did not result in improved growth or yield. In the younger stand, growth varied little between thinned and unthinned plots; in the older stand increased growth resulting from thinning was offset by greater storm damage. Undesirable hardwood development was also increased by thinning.

Fenton, Richard H., and Karl E. Pfeiffer.

1965. **Successful Maryland white pine—yellow poplar plantation: its response to thinning.** J. Forestry 63: 765-768, illus.

A plantation of 85 percent white pine and 15 percent yellow-poplar established near Baltimore, Md., in 1912 has proven unusually successful. Of four thinning intensities applied when the stand was 25 years old, the lightest thinning—equivalent to a 12-foot spacing—resulted in largest net increments in board-foot and cubic-foot volumes, the greatest total board-foot volume at 50 years, and no epicormic branching on yellow-poplar such as developed at the wider spacings.

*Fenton, Richard H., and Edward I. Sucoff.

1965. **Effects of storage treatments on the ripening and viability of Virginia pine seed.** U. S. Forest Serv. Res. Note NE-31, 6 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

A study of Virginia pine seed ripening revealed that seed becomes sufficiently viable 2 months before seedfall to warrant collection for routine use. A change in cone color from green to purple and a drop in specific gravity to 1.00 or less indicates that cones are ready for collection.

Filip, Stanley M.

1965. **Cost of chemical frill-girdling under an intensive management program in northern hardwoods.** NE. Weed Contr. Conf. Proc. 19: 563-569.

Tests of various chemical frill treatments revealed that sodium arsenite in complete frills produced nearly 100-percent kill in 2 years; partial frills were nearly as effective. A mixture of 2,4,-D and 2,4,5-T produced 82-percent kill; 2,4,5-T alone and machine girdling were the least promising treatments. Regression equations were developed relating frill-girdling time to basal area or to the product of average diameter times the number of treated trees.

*Ford, Robert P., Robert L. Talerico, and D. Gordon Mott.

1965. **A field test of procedures for evaluating and scheduling white-pine weevil control.** U. S. Forest Serv. Res. Note NE-37, 4 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Procedures recently developed to integrate biological and economic information for decisions on if and when to schedule white-pine weevil control in white pine plantations were tested in 32 stands in New England, New York, Pennsylvania, and Virginia. The trends of weevil infestation were correctly predicted within the specified confidence level in all areas except Virginia. The number of stands requiring weevil control to obtain management objectives was shown, and the degree of profitability cases was estimated. Further work is needed to extend these evaluation procedures to natural pine stands.

*Gilbert, Adrian M.

1965. **Stand differentiation ability in northern hardwoods.**

U. S. Forest Serv. Res. Paper NE-37, 34 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Paper birch, yellow birch, and sugar maple were found to vary in their ability to differentiate into classes based on diameter, height, crown class, and quality; these differences were modified by age and site. The better quality stems were found almost exclusively in the main crown canopy. Paper birch maintained higher percentages of dominants and codominants than the other species. Early cleanings may be necessary to maintain a greater percentage of the desired trees in the upper crown canopy.

*Godwin, P. A., and T. M. ODell.

1965. **The life history of the white-pine cone beetle, *Conophthorus coniperda* (Schwarz).** Entomol. Soc. Amer. Ann. 58: 213-219, illus.

Describes the successive life stages, seasonal development, and behavioral activities of the cone beetle, based on studies in the New Haven, Conn., area in 1958-60.

Gould, Ernest M. J. Jr., and William G. O'Regan.

1965. **Simulation: a step toward better forest planning.**

Harvard Forest Paper 13, 86 pp.

Presents a simulation model for an operating forest unit that can be used to compare probable outcomes of forest-management alternatives. Contains the details of the computer program, which can be used as presented or modified to meet special needs.

Graber, Raymond E.

1965. **Direct seeding white pine in furrows.** In *Direct seeding in the Northeast*. Univ. Mass. Coll. Agr. Exp. Sta. Symp. Proc: 99-101, illus.

In a test of direct seeding, it was found that the heavy shade of a pine overstory conserved soil moisture and resulted in the establishment of many more seedlings than did the exposed conditions on open land or the partially shaded conditions under sprout hardwoods. There were no differences between spring and fall sowing, although a partially ineffective seed coating resulted in heavy losses of fall-sown seeds to rodents.

*Graber, Raymond E.

1965. Germination of eastern white pine seed as influenced by stratification. U. S. Forest Serv. Res. Paper NE-36, 9 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

In tests of various stratification procedures, length of stratification was the most important factor. Nearly full germination occurred after 30 days regardless of temperature or seed source. Most rapid germination was by seed treated for the longest period (90 days).

*Grisez, T. J.

1965. How management can improve small woodlots in the Poconos. Pa. Forests 55(1-2): 13-15, illus.

Describes the yield of forest products obtained from two small woodlots on which 80 percent of the growth was harvested annually. The alternatives open to small woodlot owners are discussed, illustrating how income varies depending on how much of the work the owner does himself.

Grisez, T. J., and H. J. Huntzinger.

1965. Direct seeding studies with black cherry. In Direct seeding in the Northeast. Univ. Mass. Coll. Agr. Exp. Sta. Symp. Proc.: 41-43.

Reviews recent experiments on black cherry seed handling and field sowing. Ripe, cleaned seed that had been kept continually moist before and during stratification germinated best. In field sowings, seedbed preparation increased germination significantly. Height growth was reduced by excessive competition or by deer browsing.

*Hagenstein, Perry R.

1965. Factors in locating pulp mills.

Amer. Pulpwood Ass. Pulpwood Annu. 1965: 49-52, illus.

Presents data and concepts for evaluating national patterns of location of wood-pulp mills. Stresses importance of wood, transportation, and labor as factors in the location decision.

*Hornbeck, James W.

1965. Accuracy in streamflow measurements on the Fernow Experimental Forest. U. S. Forest Serv. Res. Note NE-29, 8 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

This study of the factors influencing streamflow-measurement accuracy revealed a total error of about 3 percent in the Fernow data. Errors were attributable to: deviation of mean check points from true values plus deviation of adjusted curve from mean check points; error in manual check of stage; and errors in compilation of data.

*Hough, Ashbel F.

1965. A twenty-year record of understory vegetation change in a virgin Pennsylvania forest. Ecol. 46: 370-373.

Describes understory vegetation changes between 1942 and 1962 in a 4,080-acre

tract of virgin hemlock-hardwood forest on the Allegheny National Forest. Heavy deer browsing has depleted the browse supply and caused a decline in understory vegetation, which will eventually endanger the scientific and educational value of the area unless relieved.

Houston, David R., and Harold G. Eno.

1965. Basal canker of white pine.

(Abs.) Phytopathol. 55: 1062.

Describes the cause of a basal canker of eastern white pine. The disease is a complex involving fungi, ants, and environment. Ants — mainly *Formica fusca* — and snow and ice cause necrotic lesions or wounds that frequently become colonized by fungi. Several of these fungi can cause girdling cankers.

Houston, D. R., C. R. Drake, and J. E. Kuntz.

1965. Effects of environment on oak wilt development.

Phytopathol. 55: 1114-1121.

Describes the effects of temperature upon the growth and survival of the oak wilt fungus, *Ceratocystis fagacearum*, in culture and in infected oak logs, and upon the development of the disease in potted seedlings. Measurements of internal tree temperatures revealed that high temperatures compared to ambient air temperatures often occurred. The possible significance of these high temperatures in relation to disease development is discussed.

*Hoyle, M. C.

1965. Variation in foliage composition and diameter growth of yellow birch with season, soil, and tree size. Soil Sci. Soc. Amer. Proc. 29: 475-480, illus.

A standardized leaf-sampling technique and foliar analysis were used to determine seasonal changes in yellow birch leaf weight, leaf moisture, and leaf nutrient content; curves are presented showing seasonal patterns for each of these factors. Foliage from trees growing on a poorly-drained Whitman soil had greater leaf weight, and higher amounts of nitrogen, calcium, and magnesium than the foliage of comparable trees growing on a well-drained Hermon soil. Diameter growth was also better on the Whitman soil.

*Hoyle, Merrill C.

1965. Forest soils in the White Mountains: what are forest soils?

N. H. Forest Notes 86: 3-8, illus.

Forest soils are defined and general descriptions are given for the various types of forest soils in New Hampshire, including rock outcrop soils, colluvial soils, shallow organic soils over bedrock, peat soils, and outwash and till soils.

*Hoyle, Merrill C.

1965. Growth of yellow birch in a podzol soil.

U. S. Forest Serv. Res. Paper NE-38, 14 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Yellow birch seedlings grown in six horizons of a Hermon soil exhibited wide differences in growth. Best growth occurred in the humus. Soil analyses indicate that poor growth in the mineral soil horizons may be due to nutrient deficiencies. Treatments to improve bulk density and aeration did not improve growth.

*Hoyle, Merrill C.

1965. Additions of phosphorous to subsoil promotes root development of yellow birch. U. S. Forest Serv. Res. Note NE-42, 7 pp., illus. NE.

Forest Exp. Sta., Upper Darby, Pa.

Yellow birch seedlings grown in soil treated with lime, nitrogen, phosphorous, and potassium in various combinations indicated that a deficiency in phosphorous may limit root development in a sandy-loam subsoil. Apparent phosphorus deficiency may be due to small total amounts of phosphorous, to its presence in unavailable forms, or to antagonism with high levels of aluminum.

*Jordan, James S., Donald Hagar, and William M. Stiteler.

1965. **Deer-browse production and timber-stand improvement in northern hardwoods.** N. Amer. Wildl. Conf. Trans. 30: 296-305, illus.

Browse production in northern hardwood poletimber stands was increased more than tenfold by a modified method of intermediate cutting. Felling all competing stems except crop trees yielded 141,000 twigs of browse per acre in tops and sprouts in the first year. The estimated cost was \$35-40 per acre as compared to about \$10-15 per acre when competing stems are girdled.

Jorgensen, Richard N.

1965. **Furniture wood bending. An inquiry into the theory and practice of bending wood.** Furniture Design & Mfg. 37(12): 60, 62.

A review of current practices in the wood-bending industry and the scientific facts about wood related to bending practices. Enumerates some of the unsolved problems, research needed, and some of the current work being done on the problems.

LaPage, W. F., and S. H. Foster.

1965. **The privately-owned campgrounds of New Hampshire.**

N. H. State Planning Proj. Study Rep. 7, 62 pp., illus.

Presents findings of surveys of campers using private campgrounds in New Hampshire and of management of these campgrounds. Describes users of private campgrounds. Describes campground management in terms of characteristics of the campgrounds and the management characteristics and plans of owners.

Leak, William B.

1965. **The J-shaped probability distribution.**

Forest Sci. 11: 405-409.

Derives and describes the J-shaped probability distribution, which should prove applicable to statistical problems involving tree diameter and other similar variables. The cumulative distribution function is $F(x) = 1 - e^{-rx}$ and the probability density function is $f(x) = re^{-rx}$ where e is the base of natural logarithms, $r > 0$ is the one parameter of the distribution, and $x > 0$ is the independent variable. Expressions are presented for the mean and variance; the conditional distribution, mean, and variance; and the characteristic function.

*Lindell, Gary R.

1965. **Marketing West Virginia lumber to manufacturers in other states.**

U. S. Forest Serv. Res. Paper NE-35, 20 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Report on a survey of lumber marketing, aimed to determine the buyer's needs so the producer can improve his marketing position by producing lumber designed to fill the buyer's needs. The buyer's main concern in choosing a lumber supplier was not price or delivery speed, but adherence to quality specifications.

*Lindell, Gary R.

1965. **Market opportunities for treated wooden guardrail posts in West**

Virginia. U. S. Forest Serv. Res. Note NE-36, 6 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Compare the installed costs of wooden, steel, and concrete guardrail posts on West Virginia highways. Although wood is least costly, it is seldom used because speed of post installation is of primary importance. New installation techniques may improve the market opportunities for wooden guardrail posts.

*Little, S.

1964. **Fire ecology and forest management in the New Jersey Pine Region.** Tall Timbers Fire Ecol. Conf. Proc. 3: 35-59, illus., Tallahassee, Fla.

A general discussion of the role of both wildfires and prescribed fires in shaping forest composition and quality in the New Jersey Pine Region. Wildfires have been an important factor in maintaining pitch and shortleaf pines and Atlantic white-cedar. Prescribed fire is a valuable management tool for fuel reduction and for reducing hardwood understories and litter in preparation for regenerating pine.

Little, Silas.

1965. **Direct seeding in southern New Jersey and the Pennsylvania Poconos.** *In* Direct seeding in the Northeast. Univ. Mass. Coll. Agr. Exp. Sta. Symp. Proc.: 64-67.

Reviews work done by the Northeastern Station on direct seeding of Atlantic white-cedar and pitch and shortleaf pine in southern New Jersey, and red and jack pine in Pennsylvania. Direct seeding can be successful if certain critical requirements are met such as early sowing or stratification of seeds, protection from birds or rodents, use of adequate seedbeds, and lightly covering the seeds on some sites.

*Little, S., and H. A. Somes.

1965. **Atlantic white-cedar being eliminated by excessive animal damage in South Jersey.** U. S. Forest Serv. Res. Note NE-33, 3 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Excessive deer browsing is eliminating Atlantic white-cedar from many New Jersey swamps. In a study of white-cedar reproduction, plots fenced against deer contained 57,000 white-cedar seedlings per acre as opposed to only 1,440 per acre on unfenced plots. Height of dominants on fenced plots was seven times greater.

Lull, Howard W., and K. G. Reinhart.

1965. **Logging and erosion on rough terrain in the East.** *In* Proceedings of the Federal Inter-Agency Sedimentation Conf. 1963. U. S. Dep. Agr. Misc. Pub. 970: 43-47.

Watershed research has shown that erosion, sediment in streams, and other problems associated with logging in steep terrain can be minimized or avoided. Most of this damage occurs during and immediately after logging, and the amount of damage is related to the type of cutting. Recommended practices include careful planning of the logging operation; proper location, drainage, and grade of skidroads; and timely completion of the operation on any specific area.

*McConkey, Thomas W.

1965. **White pine pruning and branch growth.**

U. S. Forest Serv. Res. Note NE-27, 6 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

No significant change takes place in rate of residual branch growth when young white pine trees are pruned, even though main-stem growth is reduced according

to severity of pruning. Trees tend to recover former balance between amount of crown and main-stem volume, but never regain it completely.

McConkey, T. W.

1965. **Intolerant species and direct seeding.** In *Direct seeding in the Northeast*. Univ. Mass. Coll. Agr. Exp. Sta. Symp. Proc.: 97-98.

Intolerant species have been successfully established by direct seeding more often than tolerants. This is apparently due to the intolerants' early and rapid germination, rapid juvenile growth, and ability to survive and grow on the poorer soils where direct seeding is often done. Tolerant species have been successful only on fertile soils, shaded sites, or soils where surfaces remain moist over extended periods.

McCreary, Mathilda, B. Cosenza, and A. L. Shigo.

1965. **Bacteria isolated from decays and discoloration in northern hardwoods.** (Abs.) *Phytopathol.* 55: 129-130.

The close association of bacteria with fungi from diseased tissue supports the view that both are involved in the decay and discoloration processes in living trees.

*McQuilkin, W. E.

1965. **Direct seeding in the Northeast — status and needs.** In *Direct seeding in the Northeast*. Univ. Mass. Coll. Agr. Exp. Sta. Symp. Proc.: 25-27.

Reviews the status of and the need for direct seeding in the Northeast, and outlines major research problems that must be solved before direct seeding can be prescribed and practiced successfully over large areas. Of several research problems, the most important needing study are methods of site preparation including vegetation control, seed distribution or placement, and release treatments a few years after seeding.

*Manthy, Robert S.

1965. **Pulpwood procurement practices viewed by forest economist.**

Amer. Pulpwood Ass. Tech. Paper 65-10: (8.321), in *APA Quart.* Oct. 1965: 4-8, illus.

Examines pulpwood-marketing systems used today from an economist's point of view. Relationships among the components of the marketing chain, the marketing functions undertaken by the marketing agents, and future pulpwood requirements and technological progress are discussed.

Marquis, David A.

1965. **Scarify soil during logging to increase birch reproduction.**

N. Logger 14(5): 24, 42.

Foresters and land managers are urged to capitalize on opportunities to scarify the forest floor during the normal course of logging, and thus create seedbed conditions that will encourage birch regeneration. Scarification should be aimed at exposing mineral soil and mixing it with the humus.

*Marquis, David A.

1965. **Regeneration of birch and associated hardwoods after patch cutting.**

U. S. Forest Serv. Res. Paper NE-32, 13 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Patch cuttings of 1/10 to 2/3 acre contained large numbers of highly desirable paper and yellow birch seedlings after 3 years. Birch seedlings were more numerous where mineral soil had been exposed than in areas undisturbed by logging. Seedling growth was best in the undisturbed areas. Competition from

weed species and sprouts and root suckers of commercial species were important in limiting the number of birch seedling able to attain a free-to-grow position.

*Marquis, David A.

1965. **Controlling light in small clearcuttings.**

U. S. Forest Serv. Res. Paper NE-39, 16 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Patterns of light and shade as they change from hour to hour in various small clearcuttings are illustrated, and possibilities for applying knowledge of these patterns are discussed. Narrow strip cuttings offer exceptionally good opportunities for the control of light exposure. A series of such cuttings appear to provide optimum environmental conditions for birch regeneration.

*Marquis, David A.

1965. **Artificial light sources differ in effect on birch seedling growth.**

U. S. Forest Serv. Res. Note NE-35, 6 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

In a test of various artificial light sources for birch seedling growth, cool-white fluorescents with an incandescent supplement gave best results. The incandescent supplement stimulated height growth, but effects on dry-weight were variable.

Marquis, Ralph W.

1965. **Literature needs of forest economists.**

Forestry Librarians Workshop Proc. 2: 11-15. Phila., Pa.

Outlines the needs of forest economists for reference literature and published analyses of forestry data, in reference to library services.

*Martens, David G.

1965. **Log grades — a key to predicting sawmill profits.**

S. Lumberman 210 (2612): 29-34.

During the past 10 years, hardwood lumber values have remained nearly stable while production costs have soared. To effectively combat this cost-price squeeze, lumbermen should grade their logs to determine the maximum purchase price for logs of different quality. Log-grading will also enable a mill operator to evaluate his sawing techniques and possibly improve sawmill efficiency.

Martens, David G.

1965. **Initial flooring preference survey shows hardwood in high favor.**

Flooring Mag. 67(6): 76-79, illus.

The share of the residential flooring market garnered by wood dropped 50 percent between 1955 and 1963. Competing materials have encroached on wood, yet a recent survey shows that more than half of the new home owners questioned preferred wood floors in both living rooms and bedrooms. Maintenance costs for wood floors were less than those for wall-to-wall carpeting.

Marty, Robert J.

1965. **Timber economics in a nutshell.**

J. Forestry 63: 124-126.

Review of *Price trends in forest products and stumpage — a case study in Sweden*, a monograph by Thorsten Streiffert. Provides brief description of timber pricing in a changing world market.

*Marty, Robert.

1965. **The mensurational characteristics of eastern white pine.**

U. S. Forest Serv. Res. Paper NE-40, 73 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Brings together from many scattered sources widely applicable mensurational relationships for estimating the site index, tree volume, and stand growth and yield of eastern white pine (*Pinus strobus* L.). A data source for foresters needing mensurational information for either forest practice or research.

*Marty, Robert J.

1965. **Low average blister-rust infection rates may mean high control costs.**

U. S. Forest Serv. Res. Note NE-28, 7 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

Likelihood of finding areas that will be seriously injured by blister-rust in low hazard zones is low; hence overall blister-rust control costs may be high in low-hazard zones.

*Northeastern Forest Experiment Station.

1965. **Report 1964.**

U. S. Forest Serv. NE. Forest Exp. Sta., Upper Darby, Pa. 77 pp., illus. A summary of research activities and accomplishments in timber management, forest insects and diseases, forest economics, forest survey, watershed management, forest utilization, forest recreation, wildlife habitat, forest-products marketing, and forest engineering. Annotated list of publications.

*Ostrander, M. D., and others.

1965. **A guide to hardwood log grading.** (Revised)

U. S. Forest Serv. NE. Forest Exp. Sta. 50 pp., illus. Upper Darby, Pa. A handbook developed primarily as a teaching aid and field reference in grading hardwood logs. Outlines basic principles and gives detailed practical applications in grading logs and cruising timber. Includes standards for various use classes. Revisions include new hardwood veneer-log specifications.

Parker, H. W.

1965. **The gas generator applied to forestry.**

S. Lumberman 211 (2632): 165-166, illus.

Elementary explanation of how a gas generator works. General facts on potential sizes, capacities, and pressure ratings of gas generators for forestry use.

Parker, H. W., and K. C. Elliott.

1965. **Fuel cells and the forestry industry.**

S. Lumberman 211 (2632): 113-114, illus.

Elementary discussion of fuel cells and their possible uses in forestry. A wheeled skidder powered by fuel cells is already technically feasible but many problems remain, requiring additional research to establish an economical and operational basis.

Pierce, Robert S.

1965. **Forest watershed management in the Northeast.**

Maine Forester 1965: 48-52, illus.

Reviews the water problems of the Northeast and the research programs that are under way to develop forest-management practices that will permit stream-flow regulation and produce the water needed for industry, agriculture, and the growing metropolitan areas.

*Pogge, Franz L.

1965. **The sextons — insect gravediggers.**

N. Y. Conserv. 19 (5): 32-33.

Why do we find so few dead animals and birds? The answer lies frequently in the nocturnal activities of the sexton beetle, or *Nicrophorus*. The article tells how two beetles transported a dead chipmunk a distance of one foot, buried it, and then raised a family around it.

*Reifsnyder, William E., and Howard W. Lull.

1965. **Radiant energy in relation to forests.**

U. S. Dep. Agr. Tech. Bull. 1344. 111 pp., illus.

This bulletin reviews, for foresters and those interested in the forest complex, the fundamentals of short- and long-wave radiation, of radiation measurement, and of certain radiation relationships important in the forest.

Reinhart, K. G.

1965. **Herbicidal treatment of watersheds to increase water yield.**

NE. Weed Contr. Conf. Proc. 19: 546-551.

Removal of vegetation on two forested watersheds, using 2,4,5-T both as a dormant-season basal spray and as a growing-season foliage spray, resulted in an increase of 7 area-inches in water yield during the first 6-month growing season. No effect on water quality was detected.

Reinhart, Kenneth G.

1965. **Frequency of streamflow measurements required to determine forest treatment effects.** In U. S. Forest Serv. Work Conf. on Analysis of Hydrol. Data. 11 pp., illus.

Streamflow data from control and clearcut watersheds at the Fernow Experimental Forest were reanalyzed to determine if measurements taken once a day, twice a week, once a week, twice a month, or once a month could be used instead of continuous records. The results suggest that, under some situations, much might be learned from relatively few measurements.

Reinhart, Kenneth G.

1965. **Streamflow records on experimental watersheds of the Northeastern Forest Experiment Station.** In U. S. Forest Serv. Work Conf. on Analysis of Hydrol. Data. 7 pp.

Areas, lengths of record in years, types of weirs, forest covers, and soil parent materials are given for 29 experimental watersheds. Climatic measurements are listed in terms of number and types of gages. Watershed treatments made and planned are described and the status of calibration is given.

Reinhart, Kenneth G., and Howard W. Lull.

1965. **Manipulating forests for water.**

Amer. Forests 71(11): 35-37, 44.

Reviews results of studies on the Fernow Experimental Forest in West Virginia where 5 gaged watersheds were subjected to different intensities of cutting and management care. Streamflow was increased appreciably by cutting, and more or less in proportion to the volume of timber cut. Care in planning skidroads as well as care in logging reduced damage to water quality.

Roehrs, D. G., and Grant Davis.

1965. **Hybrid poplars adapt to strip-mine spoils.**

Pa. Forests 55 (3-4): 28.

A test of 60 different hybrid poplar clones on bituminous strip-mine spoils

revealed that the poplars grew better than 10 other species planted on the same areas. Poplar survival and height growth increased as the acidity of the spoil decreased. Poor survival may be expected on spoils more acid than pH 3.6. The best clones had 100-percent survival and grew more than 7 feet in 2 years on the least acid spoils.

Rollinson, W. D., F. B. Lewis, and W. E. Waters.

1965. Successful use of the nuclear polyhedral virus of the gypsy moth. *J. Invert. Pathol.* 7: 515-517.

A high concentration of polyhedra of the gypsy moth virus applied by ground equipment to a small area of infested oak woodland in Connecticut caused a diseased epizootic and a marked reduction of the gypsy moth population in the treated area. A trace of virus occurred in the same area the following year. No virus occurred in nearby untreated areas in either year.

*Rule, H. D., P. A. Godwin, and W. E. Waters.

1965. Irradiation effects on spermatogenesis in the gypsy moth. *Porthetria dispar* (L.) *J. Insect. Physiol.* 11: 369-378, illus.

Detailed histological examination of normal and irradiated gypsy moth larvae and pupae revealed that spermatogenesis occurred in the larval period and that all irradiation dosages caused some cytological damage. The kind and degree of damage varied with insect stage and dosage. The appearance of normal gonadal tissues in the successive stages is described, and the effects of irradiation are depicted in detail. One or more of these effects could be related to sterility.

*Santamour, Frank S. Jr.

1965. Cytological studies in red and silver maples and their hybrids. *Torrey Bot. Club Bull.* 92 (2): 127-134.

In addition to the reported hexaploid and octoploid forms, red maple may exist as a septaploid or in an aneuploid condition. Aneuploid hybrids with silver maple are also possible. Neither euploid or aneuploid interspecific hybrids show meiotic irregularities associated with hybridity, although there may be a precocious separation of the silver maple chromosomes at late metaphase I. Interspecific hybrids go through meiosis in the spring, as in red maple. Asynopsis in an octoploid red maple resulted in a wide size range of pollen, with only the 2x or the 4x grains being functional in fertilization on different females.

*Santamour, Frank S. Jr.

1965. Rooting of pitch pine stump sprouts.

U. S. Forest Serv. Tree Planters Notes 70: 7-8.

The rooting of cuttings from pitch pine stump sprouts may be useful in propagating clonal materials from older pines. Sixty-six percent of the succulent cuttings collected in September produced roots when treated with Hormodin No. 3. No rooting occurred on untreated cuttings or on hardened-off cuttings collected in January.

*Santamour, Frank S. Jr.

1965. Insect-induced crystallization of white pine resins. I. White-pine weevil. U. S. Forest Serv. Res. Note NE-38, 8 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

Secretions from the white-pine weevil may cause crystallization of pine resins and thus inactivate the resins as a deterrent to weevil attack. A test of insect-induced crystallization revealed that most of the white pine species or hybrids whose resins did not crystallize had also escaped weevil injury. Thus resin

crystallization may be a useful criterion for selection of weevil-resistant individuals.

*Santamour, Frank S. Jr.

1965. Insect-induced crystallization of white pine resins. II. White-pine cone beetle. U. S. Forest Serv. Res. Note NE-39, 5 pp. NE. Forest Exp. Sta., Upper Darby, Pa.

A study of insect-induced resin crystallization suggests that resins of at least two white pine species (*P. monticola* and *P. peuce*) may contribute some degree of resistance to the white-pine cone beetle. These species should be utilized in any breeding programs for resistance to the white-pine cone beetle.

Sarles, R. L.

1965. Ten-year changes in selected logging and sawmilling costs. S. Lumberman 210 (2620): 28, 30.

Evaluates the 10-year change in prices of major cost factors associated with logging and sawmilling in the Appalachian Region. Most labor, equipment, and supply items increased more than 30 percent during the decade. The cost of purchasing major equipment items for typical logging and sawmilling complexes increased 46 percent and 48 percent respectively.

*Satterlund, Donald R., and Arthur R. Eschner.

1965. The surface geometry of a close conifer forest in relation to losses of intercepted snow. U. S. Forest Serv. Res. Paper NE-34, 16 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

This theoretical analysis of the geophysical and climatological processes that operate within the peculiar geometry of a conifer canopy suggests that there are large differences between an intercepted snowfield and one on level open ground. These differences appear sufficient for considerably greater water losses from the intercepted snow.

Satterlund, Donald R., and Arthur R. Eschner.

1965. Land use, snow, and streamflow regimen in central New York. Water Resources Res. 1(3): 397-405, illus.

Over a 23-year period the winter-spring high runoff regimen of a reforested watershed gradually became desynchronized from that of a comparable agricultural watershed. Following reforestation, runoff during snowmelt periods became increasingly concentrated in a shorter time and came later in the season. The desynchronization was apparent over the entire range of flow and time that was studied.

Schmidt, Robert A., and Charles L. Fergus.

1965. Branch canker and dieback of *Quercus prinus* L. caused by a species of *Botryodiplodia*. Can. J. Bot. 43: 731-737.

Describes the results of a study of a canker and dieback disease of chestnut oak in Pennsylvania, including observations on pathogenesis and morphology of the causal organism. Initial symptoms occurred in late summer or fall, and a scale insect often was found associated with diseased trees.

Schmidt, Robert A., and Francis A. Wood.

1965. Basidiospore release by *Fomes annosus*. (Abs.) Phytopathol. 55: 131.

Summarizes studies conducted in environment chambers, the greenhouse, and field, designed to determine relationships between several environmental factors

and release of basidiospores by *Fomes annosus*. Spore release is rhythmic in the absence of changes in environment, but also appears to be influenced by changes in atmospheric moisture and light.

*Shafer, Elwood L. Jr.

1965. **Deer browsing of hardwoods in the Northeast.**

U. S. Forest Serv. Res. Paper NE-33, 37 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Reviews and analyzes the situation, describes multiple-use management procedures, and suggests research studies needed in the production, utilization, and measurement of hardwood deer browse in the Northeast.

Shafer, Elwood L. Jr.

1965. **Socioeconomic characteristics of Adirondack campers.**

J. Forestry 63: 690-694.

Each of four Adirondack campgrounds had a different resident-zone pattern, but the income-distribution pattern of campers was the same. Results suggest that camping areas in the Adirondacks have individual characteristics affecting use-patterns.

Shafer, Elwood L. Jr., and Hubert D. Burke.

1965. **Preferences for outdoor recreation facilities in four state parks.**

J. Forestry 63: 512-518, illus.

Measures direction and amount of demand for outdoor recreation facilities in four northeastern Pennsylvania state parks. On both weekdays and weekends, campers differed significantly from noncampers in their preference patterns for swimming areas, fireplaces, camping facilities, and campsite spacing.

*Shigo, Alex L.

1965. **The pattern of decays and discolorations in northern hardwoods.**

Phytopathol. 55: 648-652, illus.

Describes the factors affecting the pattern of decays and discolorations in northern hardwoods. Tissues formed after wounding were seldom discolored or decayed. A distinction is made between true heartwood, which is produced by internal physiological changes, and columns of discolored wood initiated by external stimuli. The term *wound-initiated discoloration* is used to describe the latter condition.

*Shigo, Alex L.

1965. **Decay and discoloration in sprout red maple.**

Phytopathol. 55: 957-962.

Dissection and studies of red maple sprouts indicated that branch stubs were more important as infection courts for organisms that cause decays and discoloration than were parent stumps. The fungi isolated most frequently were *Cytospora decipiens*, *Phialophora* spp., *Trichocladium canadense*, and *Hypoxylon* spp. These fungi were closely associated with bacteria.

*Shigo, Alex L.

1965. **Organism interactions in decay and discoloration in beech, birch, and maple.** U. S. Forest Serv. Res. Paper NE-43, 23 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Results from physiological and ecological studies indicated that bacteria, non-Hymenomycetes, and Hymenomycetes were all important in the processes that lead to decay and discoloration in living beech, birch, and maple trees.

Once wood tissues are exposed, a succession of events begins that involves abiotic and biotic factors. Hymenomycetes invade only discolored tissues. Decay and discoloration seldom affect wood tissues that form after an infection court is created.

*Shigo, Alex L.

1965. **Pattern of defect associated with stem stubs on northern hardwoods.**
U. S. Forest Serv. Res. Note NE-34, 4 pp., illus. NE. Forest Exp. Sta.,
Upper Darby, Pa.

Defects associated with stem stubs usually advance downward, and the diameter of the stem stubs is approximately the diameter of the defect column.

Smith, H. Clay.

1965. **Effects of clearcut openings on quality of hardwood border trees.**
J. Forestry 63: 933-937, illus.

A study of border trees left in patch cuttings in West Virginia indicated that epicormic branching was more prevalent on the upper stems and on the side of the tree facing the opening. Trees of lower crown class had more epicormic branches than dominants or codominants. Epicormic branching was greatest on red oak, intermediate on black cherry, and least on yellow-poplar.

*Sopper, William E., and Howard W. Lull.

1965. **Streamflow characteristics of physiographic units in the Northeast.**
Amer. Geophys. Union Water Resources Res. 1 (1): 115-124, illus.

In an analysis of 17-year streamflow records from 137 watersheds in the Northeast, 7 physiographic units were recognized that were significantly different in annual and seasonal flows, flow duration discharges, and storm flow. Water yields from small experimental watersheds were found to correspond closely with average water yields of their respective physiographic units.

*Sopper, William E., and Howard W. Lull.

1965. **The representativeness of small forested experimental watersheds in Northeastern United States.** Int. Ass. Sci. Hydrol. Pub. 66: 441-456.

Application and extension of research results obtained from experimental watersheds to other areas raises the question: are they representative of the region in which they are located? To determine the representativeness of three of these watersheds in the Northeast a comparison was made of their streamflow characteristics with that of larger forested watersheds in the same physiographic region. Comparisons of annual and seasonal water yields, flow duration, and number and size of daily peak flow indicate that the small experimental watershed adequately represent their physiographic regions.

*Staley, John M.

1965. **Decline and mortality of red and scarlet oaks.**
Forest Sci. 11: 2-17, illus.

Reports the results of extensive studies of oak mortality in the Northeast. The condition resulted from the combined effects of several factors, including defoliation by leaf rollers, root rot, bark beetle attack, late spring frosts, drought, and unfavorable soil conditions.

*Trimble, George R. Jr.

1965. **Reducing the proportion of cull material in hardwood stands.**
N. Logger 14 (2): 26-27, illus.

In hardwood stands studied in West Virginia, 17 percent of the original stand

volume was in cull trees, and the merchantable trees removed in the first cut contained 15 to 20 percent defect. After 3 selection cuts, less than 1 percent of the stand volume was in cull trees and less than 5 percent of the volume of merchantable trees removed was defective. Cull proportions have apparently stabilized after the third cut.

Trimble, G. R. Jr.

1965. **Timber by the pound not a desirable trend for hardwood sawlogs.** J. Forestry 63: 881.

Weight scaling of hardwood sawlogs, now being advocated by some wood-products people, gives equal value to all species and log grades, both of which may have large effects on actual value. Because weight scaling does not provide a realistic appraisal of value, it is discouraging to forest-management practices aimed at producing high-quality material.

*Trimble, George R. Jr.

1965. **Improvement in butt-log grade with increase in tree size, for six hardwood species.** U. S. Forest Serv. Res. Paper NE-31, 15 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

A study of the effect of tree size on butt-log grade provided well-defined relationships for six hardwood species in West Virginia: northern red oak, white oak, chestnut oak, sugar maple, yellow-poplar, and birch. The improvement in grade with increasing tree d.b.h. varied with species.

*Trimble, George R. Jr.

1965. **Species composition changes under individual tree selection cutting in cove hardwoods.** U. S. Forest Serv. Res. Note NE-30, 6 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

A study of reproduction 5 and 10 years after selection cutting in cove hardwoods revealed that, under uneven-aged management, the proportion of sugar maple will increase appreciably and the proportion of yellow-poplar, red oak, and black cherry will decrease to a point where these species are no more than minor components of the stand.

Waters, W. E.

1965. **Review — White pine weevil attack by Connola and Wixson.** Bull. No. 389 N. Y. State Museum and Science Service. Entomol. Soc. Amer. Bull. 11: 95.

Reviews the subject paper analytically, points out contradictory or puzzling interpretations, and cites possible usefulness of the primary findings to the pine planting program in New York.